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CONTENTS

How Woomera Got its Name	Len Beadell	1
Lake Eyre	Vince Kotwicki	6
An Interesting and Unusual Phenomenon associated with Downslope Winds	Ian Holton	12
Rainfall Distribution in the Mitcham Council District	Elizabeth Caldicott	26
Some Reflections on Antarctic Meteorology	N.A.Streten	32
1993 in Antarctica	Tony Vaughan	37
A Relationship between Adelaide Rainfall and the Lunar Calendar?	Mrs C.O.Trenorden	46
A Weatherwise Mariner asks Why?	Robert J.Symon	56
Wake-up and Cover-up!	Peter Glade-Wright	58

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How Woomera Got Its Name

Len Beadell.

Extracts from a talk entitled **"Too Long in the Bush"** given by the late Len Beadell to the Australian Meteorological Association at the 25th Anniversary Dinner Meeting on 10 October 1994 as transcribed by John Pethic. The Association remembers with affection and sadness a great and historic Australian, who passed away a short time later, in 1995.

I was standing at my campfire over 30 years ago 900 miles west of Alice Springs on a freezing cold July night and I turned to the fellow alongside me and I said, "Is there something wrong, -.you got anything troubling you?"
He said, "No, why do you think that?"
And I said, "Oh it's just that you haven't said anything to anyone since February'.
He said, "Oh well, you don't have to say anything do you?"
And I said, "Oh, no, I don't suppose so."
I left it like that until October when I said to him, "Are you sure there's nothing wrong?"
He said, "You're always picking on me."

This all happened eight years after we were driving up the old dirt Stuart Highway to Alice Springs when we came to an obstruction in the middle of the road. Right in the middle of the road there was the biggest truck I had ever seen, bogged down to its headlights. Right smack in the middle of the road with a thicket of mulga scrub either side. No-one could get around it. There was nobody there of course, but we just happened to have a bulldozer with us....and a Caterpillar grader and three three ton trucks, steel cables and my little Landrover. We hitched all this up to this great big 40 ton truck and pulled it bodily out of the bog and parked it neatly alongside the road on a rocky rise. Then we bulldozed a lot of dirt into the great big hole he had left in the middle of the road and rolled it in and graded it over and compacted it with the trucks. And we went on our way leaving behind 300 yards of the best piece of road anywhere between Alice Springs and Adelaide. I often wonder what happened because I found out later that when the driver saw what he had done, he walked into the nearest sheep station 40 miles away, hitched a ride on a mail truck into Oodnadatta, went down on the railway and told his boss he was quitting.

The boss said, "Where's the truck?"
And he said, "Oh, you'll find it on the Alice Springs road."
And I often wonder what happened when the boss went up and found his truck neatly parked alongside the best piece of road between there and Alice Springs.

On that occasion we were on our way to make what is now the first inroad into that country in those latitudes near the SA-NT border through the Musgraves, Manns, Petermanns and Tomkinson Ranges out to the Rawlinson Ranges. This all had its roots over 47 years ago when they asked me casually if I would like to go and start a rocket range. They said, "Will you start a rocket range?"

And I said, "Yes, I can't think of anything better. I always wanted to start a rocket range. Where do you want this rocket range?"
They said, "Ah we don't know that."
And I said, "Oh well, we'll find somewhere I suppose, and when do you want it?"
"Now - straight away."

This was the year after the second world war ended, 1946. And then I suddenly had a thought and said, "What is a rocket range?" And they didn't know that either. It all sounded a bit vague to me.

But they said. "We might have something that could help you. A man has been sent over from England by Sir Winston Churchill to search the British Empire to see if he can find an area big enough to test British missiles....because during the war it became apparent that Britain needed better weaponry to conduct any defence....and we want to test out these rockets....and this man, by the name of General Sir John Evans, has come. He's been sent around the world by Sir Winston Churchill to see where he can find an area big enough. He's in Adelaide right now so if you go there and find him he might even tell you what they want."

And I thought, "Well that's something anyway." So at the end of 1946 I came to Adelaide to find General Sir John, and they told me what he looked like and I thought well when I see him I'm not going to miss him. I thought I've never seen anyone that fits the description they have given me. And I got within 300 yards of him in North Terrace and I saw him straight away - eight feet high and seven inches wide.-.that'd have to be him. So I went over to him and I tapped him on the knee, and said, "I've come to start a rocket range."

And he said, "By jove, that's rather good."

I thought, well that's got rid of that formality, "What do you want?"

He said, "We need a big area....a huge area....where there's nobody. We looked at northern Canada. They had an area there but it was hopeless...terrible climate...blizzards and snow. So I've turned to Australia"

Being an Army General he came to the Australian Army Survey Corps for assistance to start this rocket range. He went to the Director of Survey in Melbourne and at that time I was in the NT with the first combined scientific expedition into the Alligator River country in Arnhem Land doing astronomical observations for fixing the positions of their new scientific discoveries in geology, botany and so on. That kept me in the army for that extra year and when I went down to Melbourne he said while you have been away this General Sir John has approached us for help in starting a rocket range. And being a surveyor he knew that such a thing like that would rely entirely on astronomical observations for position of latitude, longitude and directions. He knew I was quite fluent in doing that, because I had been doing it in the Territory and giving lectures to the Army Survey Corps in New Guinea during the war.

Anyway as I said, when I came over to Adelaide I asked the General what he wanted. He said, "We want the longest piece of country we can find in the world with nothing in the way under the rockets flying over the ground. They have a rocket range in Wales at Aberforth in Cardigan Bay but when the rockets are launched they fly over land for nine inches and then they are over the Irish Sea. They fall into the sea and they can't retrieve them and they don't know what has happened to them, and they want something other than that."

So I said, "I know where there's a million square miles....I'll talk about miles because I don't know what they are in kilopascals....mmm....I know where there is a million square miles of absolutely nothing but sandhills and spinifex."

And he said, "I say, that's more than we've got in Gloucester."

I said, "I think it might be, but I haven't seen Gloucester." A long time later I went over and stayed with him where he lived Gloucester, and I discovered that Gloucester was two miles across. I almost missed it. I went to see him and he had been used to those sorts of distances all his life, little bits of distances, and so when I talked about a million square miles of nothing it sounded as though it was pretty right to him. So we looked at a map of Australia, and we saw that about a hundred miles the other side of Pt Augusta, seemed as far back across Australia as we could come with any sort of safety. That would leave almost one and a half thousand miles in a straight line across Australia in a certain direction and come out in the middle of the eighty mile beach between Broome and Pt Hedland. Nothing in the way except in the first couple of hundred miles there were a few sheep stations and from there on for well over a thousand miles there was nothing whatsoever to hurt. If we had have gone a little bit to one side of this corridor across Australia we would have been hitting Halls Ck and Darwin, a little bit to the other side we would have been hitting Geraldton and Port Hedland. But there was this one corridor which was free of any habitation whatsoever, so we thought now that's a good area to give the longest piece of range we could get. A hundred miles the other side of Pt Augusta looked about right.

So 47 years ago I drove into this general area with a jeep and a three ton truck to start the project which was to become Woomera. It wasn't Woomera then, it was just my camp on the plains. A lot of you in this particular group may have been to Woomera. And if you have, you would have the same impression that I did when I first got to the general area we were looking at. I had the feeling that I wasn't hemmed in!! I very quickly found I could see a bull-ant for ten miles in any direction, unless it was crouching down. And I thought, now what a perfect area to start a rocket range, what a perfect area to start anything, there was nothing I could spoil to the horizon.

So I settled down in this area and started the project and the first thing that occurred to me when I was first starting to do this was to obtain from somewhere a starting point. You can't just go into the desert and start anything without an origin, something to refer all the work you are going to do back to - a pinpoint on the surface of the earth. That was a mountain near the camp which was eight inches higher than the rest of the plains. When I climbed up to the top of this I didn't even have to use oxygen up there. When I got up there, I found I could see a lot more of nothing from up there than I could down at my camp. So I thought, this is where I will start the project. I spent a

whole week up there reading angles on the stars, doing calculations of latitude and longitude to get the pinpoint which I could relate everything to. Nobody knows really, I don't suppose, and nobody cares, and it probably doesn't matter anyway that everything we did at Woomera, Maralinga, Emu and Giles was related to this one point. So when you start a firing range of any sort you have to decide on a centre line of shooting, like a rifle range and so on. You have to decide, "I'm going to shoot in that direction.". The only way I could find a line was to pick a point in the middle of the Eighty Mile Beach on the Indian Ocean, one and a half thousand miles away and calculate a bearing across Australia which would become the centre line of fire.

I didn't know at the time that the centre line that I calculated would govern the entire shape of things to come in central and western Australia. I didn't know that at that time because I thought that the only rockets I'd ever heard of were the ones where you put the sticks in a milk bottle and light the fuses, and they go off and...."Oh that's pretty"....and the sparks would go away and everyone would go away. I really thought it was going to be a one night fireworks display. But every now and then General Sir John would come up to my camp to see how I was getting on. He was required by Sir Winston to report the progress being made on this rocket range on the other side of the world.

The only way he could do that was to come to my camp to see for himself. In those days there was a set of wheeltracks up to where I was camping with very deep wheel ruts made by the 1870-80 coaches dragging out supplies for the Tarcoola gold fields and beyond. He came with a car with very little clearance and so he left bits of it all the way from Pt Augusta. He was a very polite man, and wherever he was in the world he liked to blend in and look like the inhabitants. Well he read that we wear shorts in Australia, so he went and bought some, about three feet wide. He bought them at Moore's near Victoria Square just after it burned down, and he got quite a bit off actually. Being an army general he couldn't look untidy so he pulled a pair of snow white socks up to his knees. The effect was....this pair of shorts had these two white sticks coming out of the bottom and he was so tall that he couldn't go where he wanted to all at once. The bottom would set off and the top would look down and decide to follow along later.

So when the car stopped the first thing that got out was this thing. I didn't know what it was. I thought it was a television set, I hadn't seen one before,and thought what an unusual thing to send up to me, television hasn't even reached Australia yet. After a while the rest of the general came out of the car. I was down a slight slope and I could see knees, bare skin, three sixteenths by an inch and a quarter. And I thought, they're shorts he's wearing, you can tell. He had spoilt the whole effect by having the shorts made out of red velvet, but he was doing his best to be polite. A man had come with him by the name of Major Wyn Williams. He had come with the express purpose of writing the history of this rocket range from the word go to thereafter. He came to me and said, " I've got to compose these cablegrams back to the UK. I've got to refer to this place vaguely as Beadell's rocket range site in Australia. It's a long thing to put in a cablegram. Could we find a name for it."

I said, "I don't really think it's worth a name. If you go into a paddock and let off crackers you don't name the place.

But he said, "Oh it would be nice to have a name and I've brought something that could help, a dictionary."

And I didn't have one of those....I wondered how I had done without one for all these years. And it turned out to be an Aboriginal - English dictionary.

Lake Eyre

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Introduction

Australia has the dubious distinction of being presently the most lakeless and waterless continent. Salt lakes ('dry lakes' would be probably a more accurate designation) are, however, plentiful and in recent years they have received considerable attention. The largest of them, Lake Eyre - in fact the largest ephemeral lake in the world - which has its own enigmatic fascination to limnologists the world over, was considered permanently dry since its discovery in 1840 until its first recorded filling in 1949. In the decades that followed, fillings of Lake Eyre were still considered as isolated, unique and independent events. Only recently have they been looked at as a predictable manifestation of the world-wide atmospheric and oceanic circulation, of which the El Nino-Southern Oscillation (ENSO) is one of the most significant phenomena. It is suggested that Lake Eyre floods are a physical manifestation of strong and positive Southern Oscillation phases and are usually out of phase with the Pacific Dry Zone rainfall and El Nino events. Links have been found between ENSO and large-scale precipitation patterns and 17 global core regions that appear to have a clear ENSO-precipitation relationship have been identified. Five of those are located in Australia and two of them, eastern Australia and central Australia, cover the entire Lake Eyre basin.

Lake Eyre Basin

Lake Eyre is the terminal point of the great continental drainage system which spreads over 1.14 million sq. km. of arid central Australia. The Lake Eyre basin is mostly flat with extensive areas of sandy and stony deserts. There are regions with some relief near its boundaries, but only 30% of the area is elevated more than 250 m a.s.l. Catchment area to lake surface area ratio AC/AL = 118, significantly more than for most major closed-drainage systems in the world, and virtually identical to that of Lake Chad (AC/AL = 120) in Africa. Some hydrological parallels could be drawn between both lakes: Lake Chad has a basin of 2.5 million sq. km., about double the size of the Lake Eyre basin, its surface area is 20 830 sq. km. and its volume 72 cu. km., about twice the size of Lake Eyre in 1974. Both lakes are subject to similar evaporation rates (2000 mm per year) but the Lake Chad basin receives some 500 mm year per year of rainfall, about twice that of the Lake Eyre basin. In effect, the Chari River, Lake Chad's main tributary, carries on average 40 (19 to 54) cu. km. per year, compared to 2.4 (0 to 25) cu. km. per year of the Diamantina River, the main tributary of Lake Eyre. As a result, Lake Eyre dries up after periodical floods and Lake Chad remains permanent, despite significant water-level fluctuations.

Climate

The Lake Eyre basin lies in the arid zone which covers some 60% of Australia. However, the aridity of this region does not equal that of the Sahara or Namib and even a slight increase in rainfall would transform it into a semi-arid environment. It may be helpful to visualise here what a deficiency of water is. The Lake Eyre basin, which covers 0.8% of the Earth's land area or 4.3% of the areas without outflow to the sea, receives some three times less rainfall than the world average and is subject to some three times more intense

evaporation. Although these figures may appear at the first glance not very significant, they entail far-reaching consequences. If the amount of the fresh liquid water on Earth were distributed uniformly by areal proportions, then Lake Eyre basin would contain some 50 times more water flowing in rivers and 200 times more water stored in lakes than it currently does.

The average annual temperature varies from 21C in the south of the basin to 24C in the north, and the average maximum temperatures are 18C and 24C respectively in July, and 36C and 39C in January. The annual hours of sunshine vary from 3250 to over 3500, and the average global radiation is 600 mWh per sq. cm. per day.

Large parts of the Lake Eyre basin are poorly instrumented, but it is estimated that an area of some 500 thousand sq. km. receives less than 150 mm of rainfall per year on average. The highest rainfalls, with annual averages of about 400 mm, occur in the northern and eastern margins, where rainfall is received from the southern edges of the summer monsoon. However, this region lies barely on the periphery of the planetary monsoon system, and the Australian monsoon is erratic both in space and time.

The mean annual evaporation as measured by Class A evaporation pans ranges from 3 600 mm for the central and south western part of the basin to 2 400 mm for its eastern edge. The pan coefficient which converts pan data into evaporation from large water surfaces is of the order of 0.6 in the Lake Eyre area.

The annual evaporation rate for the filled Lake Eyre ranges from 1800 to 2000 mm. The evaporation rate from the dry lake floor (excluding the salt crust) is of the order of 170 mm per year and the net evaporation rate from the salt-covered surface of Lake Eyre at between 9 and 28 mm per year.

Groundwater

Most of the Lake Eyre basin overlies the Great Artesian Basin which covers an area of 1 700 000 sq. km. and is one of the largest in the world. Aquifers are formed from porous sandstones of the Triassic, Jurassic and Cretaceous, which crop out along the Great Dividing Range and are up to 3000 m deep in its central part. From the mountainous recharge zone, water percolates very slowly towards the terminal base level of Lake Eyre, reaching this area after a calculated travel time of up to three million years. Intakes along the arid western rim make only a minor contribution.

Apart from natural vertical leakage through the confining beds over the entire basin, natural discharge occurs from some 600 springs located in 11 groups along the western and southern boundaries of the basin, many of which appear to be fault controlled. Flows from the mound springs amount to 0.03 cu. km. per year and are thought to be only a minor discharge component. Artificial withdrawal from the basin is around 0.5 cu. km. per year, diminishing steadily from around 0.7 cu. km. in 1915. Measured flows from springs range from 0.0001 to 0.23 cu. m. per sec totalling around 1 cu. m. per sec. Salinities range from 700 to 1 400 g. per cu. m., pH from 7.1 to 8.0 and water temperature from 30 to 40C.

Tributaries of Lake Eyre

The drainage system of Lake Eyre is exceptional for the persistence of an extensive network, despite its inclusion in the driest parts of the continent. This is a result of the favourable structural disposition of more effectively watered peripheral uplands combined with centripetal lowland slopes on weak and generally impervious rocks, leading to the

downfaulted terminal basin. Much of this drainage is disconnected as a relict from linked river systems which developed under higher rainfall conditions and which became disorganised, under the present arid climate.

The lake is fed mainly by its eastern tributaries, the Cooper Creek and the Diamantina and Georgina rivers system. Significant runoff originates in the desert west of the basin, which is drained by the Neales and the Macumba. Under the current climatic conditions only some 68% of the basin contributes water to the lake - although in pre-Quaternary time, under more moderate and wetter conditions, drainage from the Simpson Desert and Finke River catchments would have contributed also.

All streams are characterised by extreme variation in discharge and flow duration. Mean annual runoff of the basin is 4 cu. km. or 3.5 mm in depth, the lowest of any major drainage system in the world. This is significantly less than the 57 mm for the whole of Australia and only 1.5% of the mean annual runoff of all the land areas of the world, estimated as 247 mm. The aridity of the basin is more graphically demonstrated by its specific yield of only 10 cu. m. per sq. km. per day in comparison to the Nile or the Amazon which have specific yields of 115 and 2200 cu m. per sq. km. per day respectively.

In arid central Australia 15-20 mm of rain of moderate intensity can cause a flow in minor streams that lasts only for an hour or two. Such a flow may occur as often as five times each year. However, about 50 mm is needed for a full channel flow and such falls can be expected less frequently than once a year. Major floods in the Lake Eyre basin result from annual rainfalls which exceed 500 mm: the runoff coefficient in such years approaches 0.05.

Eastern tributaries

Eastern tributaries of Lake Eyre originate in more humid areas and flow quite frequently. However, only a small proportion of these flows reach Lake Eyre, due to very high transmission losses. The Cooper Creek for example can lose up to 107 cu. m. *per* km. in its central reach, filling innumerable salt lakes and interdune corridors of the Tirari Desert. Usually the Cooper Creek terminates at the Coongie Lakes, the only permanent wetlands within the 5 million sq. km. of arid central Australia. The Cooper Creek only reaches Lake Eyre on average, once in six years. The transmission losses of the Diamantina River are usually much lower. The mean velocity of floods is 12.5 km per day for the Diamantina and 3.1 km per day for the Cooper.

Water quality analyses in the central reaches of the main tributaries show that the mean annual inflow of 4 cu. km. transfers some 250 000 t. of salt into the lake, some 0.2 t. per sq. km. per year in comparison with the world average of 26 t. pre sq. km. per year. On this basis, the period of accumulation represented by existing salt crust appears to be as short as 1600 years. The load of suspended solids is of the order of 1.5 million t. per year, the equivalent of a 0.15 mm layer over the lake. The specific suspended sediment load is 1.5 t. per sq. km. per year, very low in comparison with the world average, of 90 t. per sq. km. per year.

Western tributaries

The hydrology of the western tributaries is largely unknown. Several major rivers carry water infrequently, possibly only once in ten years. Flood volumes can be, however, enormous: for example in 1984 and in 1989 Lake Eyre received some 8 cu. km. from

western tributaries in three days, which implies discharges of the order of 30 000 cu. m. per sec., or one-sixth that of the Amazon.

Lake Eyre

Lake Eyre, whose lowest parts lie 15.2 m below sea level, consists of two sections: Lake Eyre North and Lake Eyre South, joined by the narrow Goyder Channel. Lake Eyre North was a permanent saline lake from 5000 to 10 000 years ago and entered a playa phase between 5000 and 3000 years ago.

A salt crust up to 460 mm thick covers the southern part of Lake Eyre North. The 400 million t. of salt deposited in the lake dissolve completely at times of major inflows. The origin of this salt is a matter of considerable discussion, as the possible sources are very diverse ranging from marine aerosol transport ("cyclic salt") to rock weathering and groundwater discharge from aquifers deposited during the Cretaceous marine transgression that inundated central Australia.

The presence of several old beach lines, 0.7, 1.6 and 2.8 m above the 1974 water level, indicate the occurrence of previous unrecorded major inflows. The term "full" should therefore be used cautiously in relation to Lake Eyre. The above levels would represent approximate storages of 35, 48 and 67 cu. km. respectively and the potential available storage to sea-level is more than 200 cu. km., i.e. almost seven times greater than the 1974 storage.

Fillings of Lake Eyre

Lake Eyre lies in a remote and desolate area. Despite the current level of interest in the lake and its hydrology, very little data on its fillings have been collected, and many minor floodings have escaped attention.

Palaeohydrology

The existence of a large lake in central Australia is traceable to the middle Jurassic (150 million years before present (BP)) when freshwater Lake Walloon occupied the central eastern part of the continent. In the late Cretaceous (85-75 million years BP) it shrunk to a smaller, 500 000 sq. km. Lake Winton, which in the early Miocene (21 million years BP) assumed a position closely resembling the recent location of Lake Eyre. Lake Dieri, a Pleistocene "greater Lake Eyre" underwent large scale climatic variations, entering into the Recent epoch as a dry salt pan subject to occasional flooding.

A longer period of constant filling of Lake Eyre occurred probably in the late Pleistocene, during a wetter climate in southern Australia, between about 45 000 and 25 000 BP. This was followed by a phase of lake contraction, dune building and desiccation. Since European occupation, the climate has been almost equivalent to that of the driest phases of the last 10 000 years.

Recorded fillings

The existence of water in Lake Eyre was first reported by Ross in 1869 and then by Halligan in 1922. However, their reports were dismissed as observation errors. Madigan, who explored the area after a long drought in 1929 was convinced that the lake is permanently dry. The first reliable record of filling was in 1949-50, when Lake Eyre North reached a peak storage of 21 cu. km. This was followed by a series of minor floodings in 1953, 1955, 1956, 1957, 1958, 1959, 1963, 1967 and 1971, leading to a most significant

flood event which began in 1973, reached its peak in 1974 and persisted until 1977. Lake Eyre North reached its highest recorded level of -9.09 m AHD in June 1974, and the equilibrium level of -9.5 m AHD between both lakes was achieved in October 1974. The peak combined storage was 32.5 cu. km.

The last decade brought two unexpected events. The filling of 1984 with a total volume of 10 cu. km. was a relatively minor one, but it proved that the western tributaries can fill Lake Eyre in a matter of days. Lake Eyre South this time filled first - an event never previously recorded and considered to be extremely unlikely - and overflowed to Lake Eyre North. In 1989 this event was repeated, coinciding with the filling of the second largest Australian playa, Lake Torrens, which filled for the first time since 1878.

The wet spell continued into 1990 when after some of the most devastating floods in Australian history, water from the Cooper Creek reached Lake Eyre for the first time since 1974.

Modelled fillings

The inflows to Lake Eyre in the period 1885-1984 were reconstructed using a rainfall-runoff model on the short streamflow records available, and then extending modelling for the period in which only rainfall data were available.

The modelling clearly showed that the inflows to Lake Eyre North were relatively frequent and occurred on average every alternate year in the period investigated. The mean annual inflow was 3.8 cu. km., with a standard deviation of 6.2 cu. km.. Annual inflows shown in Figure 1 have a slight downward trend of 0.005 cu. km. per year coinciding with the decrease in lake water levels in the Northern Hemisphere estimated as 30 cu. km. per year since 1940. Global warming need not necessarily be the cause, as in the period 1910-1940 the said decrease was of the order of 50 cu. km. per year. For more illustration, the Caspian Sea dropped its level by 3 m in 1860-1970, the Dead Sea by 4.5 m in 1885-1960 and the Great Salt Lake by 3.5 m in 1850-1960, but the Great Lakes in turn, are at their highest in decades. The overall mechanism causing lake level variations throughout the world is clearly not recognisable at this stage.

The Diamantina and Georgina rivers system, which covers only 32% of the Lake Eyre basin, contributed 65% of the total water entering the lake. The mean annual inflow from this source was 2.4 cu. km., with a standard deviation of 3.8 cu. km. The input from Cooper Creek and from other tributaries was 0.63 and 0.72 cu. km. per year respectively.

Rainfall-runoff modelling undertaken and a series of recent fillings show that Lake Eyre North fills much more frequently than was previously thought. In fact a return period of a 10 cu. km. inflow is 8 years. Such a volume of water covers almost the entire surface area of Lake Eyre North and evaporates during the following year.

"The Greenhouse" effect

The behaviour of such a delicate system under the influence of enhanced "greenhouse" processes is a subject of justifiable curiosity. Although future fillings of Lake Eyre cannot be presently predicted with any degree of confidence, the effects of the possible climatic changes can be evaluated.

The most frequently quoted forecasts today suggest that in Australia by the year 2030, the temperature will have increased by 2 to 4°C, summer rainfall will increase by 50%, winter rainfall will decrease by 20% and overall wind speed decrease by 10 to 20%. As more

than 95% of total inflows to Lake Eyre are generated during the Australian summer (December to March), the change in winter rainfalls will have relatively little effect on the frequency of filling of the lake. The effect of other factors on runoff tend to cancel each other.

The 50% increase in the summer rainfall would have by itself a substantial effect on streamflow, increasing it possibly two- or threefold as it is known that an increase of 25% in precipitation and a decrease of 1°C in temperature can increase the simulated runoff by 250%. The central reaches of all tributaries would be inundated more frequently which would significantly intensify the evaporation transmission losses, where a change of 1°C corresponds to a 4% change in evapotranspiration. The larger areal extent of evaporating water surface and ground would, however, be partially compensated by the lower wind speed which would reduce evaporation. Although it appears that major tributaries will probably be flooded more often in their upper and central reaches, it is unclear whether their waters will be reaching Lake Eyre more often due to the increased transmission losses.

An Interesting and Unusual Meteorological Phenomenon Associated with Downslope Winds

Ian Holton
Bureau of Meteorology
8 February 1990

Introduction

Downslope winds have interested and puzzled both lay and professional weather persons for many centuries. The mysteries of their origin and behavior are still the subject of debate among the many downslope researchers. Unusual local names for these winds add to their fascination. Some well known local names date back to Greek and Roman times, for example, the "bora" of the Adriatic coast: from the Greek "bopeal" (north wind) (Yoshino; 1976), and the "foehn" of the European Alps: probably from the Latin word "favonius" (west wind) (Brinkmann; 1974), while the "chinook" of North America comes from the name of a local Indian tribe (Glenn; 1961). A list of other less well known downslope winds, includes such interesting names as; "zonda" of Argentina, "halny wiatr" of Poland, "helm" of the British Pennines, "hiroro-kaze" of Japan, "doctor" of Jamaica, "reshabar" of southern Kurdistan, "gully wind" of South Australia, and "Santa Anna" of California.

A universally accepted definition of a downslope wind is hard to locate in weather literature, as such a wide variety of local research criteria have been used over the years. In this paper most of the examples discussed have the same common characteristics found by Atkinson (1974) in his discussion of "foehn" (warm) and "bora" (cold)- type winds. These typically:

Start suddenly, and are strong, gusty and fairly constant in direction.
Have a nocturnal maxima.
Occur when a stable layer is present at or just above ridge-top altitude.

In addition, the very name of downslope winds implies that an acceleration occurs during the leeward descent of the airflow.

Many theories and explanations for the occurrence of these winds have been published over the past hundred years. However, the two most popular mechanisms currently invoked to explain their formation involve hydraulic flow and leewave amplification.

In hydraulic flow theory there is a transition from sub- to super-critical flow at the mountain crest and the stream accelerates down the leeslope. In a similar way water flows over a dam wall and accelerates in its downward plunge to the stream below. This hydraulic water analogue when applied to the atmosphere requires a two layered structure to be present. A cold dense airmass near the surface, with a warmer, less dense airmass above. This basic hydraulic model has been used to explain downslope flow by a number of authors (e.g. Kuttner,1939, 1958; Arakawa, 1968,1969; Houghton and Kashara, 1968; Smith,1985)

Lee wave amplification is accomplished by the resonant reflection of wave energy between the surface and an upper reflecting layer (e.g. Klemp and Lilly, 1975; Peltier and Clarke, 1979; Durran and Klemp, 1987). This upper layer may be the tropopause or a self-induced layer formed by the action of wave-breaking above the ridge-top.

Hydraulic theory uses relatively simple physics and is supported by comprehensive observational literature, while lee wave amplification theory is dependant upon quite complex interactions of many parameters.

In this paper the author uses the basic hydraulic model to explain most of the described phenomenon, as this simpler mechanism appears to fit well with the recorded observations. The author also must admit some bias towards the hydraulic model, as this mechanism has been successfully used to explain many of the observed features of the local downslope flow of Adelaide (Holton and Grace, 1989a and 1989b; Grace and Holton, 1990). It was during the investigation of these local winds that the author's attention was drawn to several interesting and unusual downslope wind-related phenomena. While some of the features appear to be unique, many have been found to be common to other downslope wind flow situations around the world.

The aim of this paper is to describe these phenomena in fairly simple non-technical language to enable both lay and professional weather persons alike to appreciate the fascination and mystery of the downslope wind flow.

Meteorological Phenomena Associated with Downslope Winds

1. *Surface Temperature Changes*

Foehn downslope winds (where the leeside temperature rises) and Bora downslope winds (where the leeside surface temperature falls) were once thought to be caused by different mechanisms, but most modern weather researchers agree that the "relative warmth or coldness of the downslope wind ... much a function of the original temperatures of places prior to the occurrence of the wind" (Atkinson, 1971). Brunkman (1974) notes that the well-known "chinook" may cause temperature rises at Boulder, Colorado of 15-20C on some occasions and temperature falls of a similar magnitude on others.

An unusual downslope wind event which occurred at the Central Australian township of Alice Springs during the late evening hours of the 23rd September 1988, clearly showed that warm and cold downslope flow can occur on the same lee slopes (Holton et al.,1990). This particular downslope wind event was initiated by the passage of a shallow northward moving cold frontal air mass over the low, narrow, east-west orientated McDonnell ridge. At the Alice Springs observational area this ridge is only 150-250 m above the surrounding Emily Plain, and approximately 1 km in width (Figure 1).

The passage of the shallow cold front provided the two-layered structure required for accelerated downslope flow, when the colder denser air undercut the warmer less dense air. A good analogy can be seen in figure 2, a laboratory experiment by Suzuki and Yabuki (1956). In this experiment dense saline water takes the place of the cold

airmass. As the denser fluid passes over the ridge-top it accelerates down the leeslope due to gravitational forces.

An additional feature in the Alice Springs case, was the occurrence of a shallow radiationally cooled surface layer extending across the Emily Plain, but not at ridge-top. The cold front "slid" over the top of this very shallow windward airmass, and on reaching the crest, accelerated by gravitational means down the leeslope and rapidly eroded the cold, dense leeward surface layer. By these means the cold front lowered the surface temperature at the crest observational site, but raised the leeward base surface temperature as table 1 shows.

Table 1 Potential Temperature/Mean Wind Speed changes
Cold Frontal passage, Alice Springs, 23-09-88

	Windward base	Crest	Leeward base
Before front	27C, calm	36C, westerly at 4.5 m/s	22C, calm
Half hour after frontal passage	28C, variable at 1.5m/s	31.5C, sth/ly at 7.0 m/s	31C, sth/ly at 11.0 m/s
Change in Potential Temperature	+1C	-4.5C	-9C

It is apparent from the above that an observer near the top of the lee slope would have been correct in noticing a "bora" downslope wind, while an observer at the leebase would be equally correct in reporting a "foehn" downslope wind.

A further conclusion is that the "warm" downslope effect at the leeside base, was in fact the result of the gravitational acceleration and eventual overshoot of the "cold" dense frontal airmass down the leeslope.

These observations quite clearly show that the temperature fall or rise noted by any downslope wind observer is directly related to the initial temperature prior to the commencement of the downslope flow.

2. *Ridge-top Temperature Changes*

A common observation during downslope flow is of an inversion (rise of temperature with height) at or just above ridge-top altitude. This inversion is the boundary between the two different density airmasses found in hydraulic flow. All of the published examples of near ridge-top inversions known to the author appear to be measured at some point to the windward or leeward of the actual ridge-top. Therefore the inclusion in this paper of what appears to be unique radiosonde records of a "capping" inversion measured at the ridge-top itself during a downslope situation in the Adelaide, South Australian region, is of significant interest.

On the 3rd February 1988, during a study of Adelaide downslope flow, a strong ridge-top capping inversion was recorded by a radiosonde flight released from the Mt. Lofty summit (figure 3). This observation was combined with other windward/leeward radiosonde flights and the airborne observations of a motorised glider, which enabled a fairly complete cross-sectional analysis to be undertaken (figure 4). These observations show the main features of the Adelaide downslope flow, i.e., windward adiabatic ascent of near surface air is evident, together with adiabatic descent of higher than crest level air. These two airflows converge to form the strong ridge-top capping inversion, and this cool, dense negatively buoyant airmass beneath the inversion accelerates down the leeslope in a shallow thin hydraulic downslope layer.

At the time these observations were made, a leeside base site, Wattle Park, directly beneath the Mt. Lofty summit site, reported a maximum downslope ten minute mean speed of 17 m/s (34Kt).

Further observations of another downslope event in the same area on the 15th February 1989, appear to show the ridge-top capping inversion oscillating below and above the Mt.Lofty summit site. The summit surface temperature trace shows irregular variations of 7 to 9C throughout the night, while a lower ridge-top site shows only the expected nocturnal minimum temperature trend (figure 5).

Nocturnal temperature changes at the Mt. Lofty summit site have been found to strongly influence leeside downslope flow strength (Grace and Holton, 1988). A temperasture drop at the summit is followed by a leeward downslope wane. This relationship between Mt. Lofty temperature and leeside downslope wind speed has been successfully incorporated into local forecasting aids (Holton and Grace, 1989a, 1989b).

Another interesting phenomenon associated with these ridge-top temperature oscillations are extreme humidity variations. On the 13-14th November 1987, the Mt. Lofty dew point was noted to rise and fall during the nocturnal hours up to 40C, the higher dew point being recorded at the time of a lower temperature oscillation and vice-versa.

Variations in the Mt.Lofty crest top temperature and humidity can be explained by oscillations in the altitude of the capping inversion. When the inversion is above the crest site, near surface cool and relatively moist windward air is being adiabatically lifted up and over the crest site. Conversely, when the inversion is at an altitude below the crest site, upper level warmer and drier air is flowing over the crest site. Fom this it would appear that downslope hydraulic flow may sometimes occur to the lee of lower ridge-top areas of the range, but at the same time will not occur to the lee of the higher ridge-top areas. This has in fact often been observed in the general Adelaide region (Grace and Holton, 1990). This explanation would account for the maximim Bora wind occurrence in the lee of the Senj valley region of the former Yugoslavia (Yoshino, 1976).

3. *"Roaring" Wind and Large Spatial Downslope Speed Variations*

One of the most noted world-wide downslope phenomena is that of an audible wind "roaring", heard when the observer is located on the light wind side of what in hydraulic terminology os called an "hydraulic jump". The hydraulic jump is an "abrupt increase in fluid level" ... in the atmiosphere case this is the lower denser airmass ... "characterised by larger velocities and shallower depths upstream compared to those downstream" (Grace and Holton, 1990). A simple experiment can be done at home in a hand basin that has a flat bottom. If a tap is run into the basin (or a jug poured) away from the open plug hole, an hydraulic jump will form at a distance from the water impact point. This "hydraulic jump ring" will show the characteristics just mentioned. An observation point downstream from the hydraulic jump may have calm or even reversed wind flow, while strong downslope flow may be heard "roaring" nearer to the leeside base of the hills.

Several examples of this unusual effect have been reported:

1. Helm downslope wind, Crossfell, England. (Manley, 1945)
   "Clearly too, the extreme gustiness of the wind on the margin of the calm zone beneath the bar (a Helm cloud feature) ... with an audible roar of the wind, but a short distance ... toward the fell. This roar is very characteristic, and can often be heard upwards of a mile away."

2. Antarctic "katabatic" downslope flow Commonwealth Bay, Antartica. (Bell, 1956)
   "A coastal station will once more be in a region of light wnds ... but it is in this case that strong winds may be both audible and visible higher up the slope, as noted by observers in the Antarctic and Greenland."

3. Antarctic "katabatic" downslope flow, Davis, Antarctica. (Lied, 1964)
   "The distinctive roar of the wind upslope, similar to the passing of a distant express train, was always a feature ... walking downslope with the wind behind him ... the transition from highly turbulent to calm or light and variable conditions usually occurred over a distance of only about 5 yards."

3. Scarp downslope wind, Pearce, Western Australia.
   The officer in charge of the Pearce meteorological office, Mr L. Van Burgel, reports that often pilots on the ground at the Pearce R.A.A.F. base airport note a roaring noise prior to the commencement of the local scarp downslope windflow.

As mentioned, this "roaring" of the wind is caused by spatial wind speed differences near the hydraulic jump zone, and several extreme spatial flow variation examples also occur:

1. Chinook downslope wind, Boulder, North America. (Lilly and Zipser. 1972)
   "As we left for the airport (Broomfield) ... gusts to 100 mph were already hitting the west side of Boulder ... we passed through the edge of the strong winds about eight miles out, and at the airport itself the anemometer was recording only a few knots."

2. North Flinders Range downslope wind, South Australia. (Taken from anemometer records collected 22-23 June, 1981,during Beverley Environmental Study, courtesy of Nigel Holmes, Dames and Moore Pty Ltd, Sydney, Australia.)

This downslope windflow case occurred during the nocturnal hours of the 22nd to 23rd June 1981. A fresh west to south west stream was evident over the North Flinders ranges, during the study period (figure 6) and no significant cloud or precipitation were evident from surface synoptic observations. The general elevation of the ridge-top at the observation point is 1200m. Mean windspeed records for the two day period revealed that windward and leeward sites exhibited westerly flow of similar strength both day and night, with a tendency for a nocturnal minimum. In contrast, Paralana, the nearest site to the eastern leebase recorde an extreme nocturnal maximum of 28m/s (56kt). The maximum mean speed difference between Paralana and another leeside plains site, South Pipeline, just 19km downstream, is an astonishing 25m/s (50kt(at 2300 local (figure 7). Extreme wind gusts would very likely accentuate this large spatial wind speed variation.

3. Chinook downslope flow, Boulder, North America. (Brinkman, 1974)

"Perhaps the most violent downslope winds which have been reported are those experienced at Boulder, Colorado, where maximum speeds of over 56m/s (112kt) and typical changes in speed from less than 5m/s (10kt) to 45m/s (90kt) in a matter of seconds have been recorded (Julian and Julian, 1969)."

4. *Temperature Changes across the Hydraulic Jump*

Equally fascinating are some of the surface temperature changes recorded across the hydraulic jump zone. In the nocturnal hours under clear skies, radiational cooling often significantly lowers the surface temperature in the lighter wind area to the lee of the hydraulic jump. However, the surface temperature in the strong wind area to the windward of the hydraulic jump does not appreciably cool, as mechanical turbulence mixes any radiational cooling over a much thicker atmospheric depth.

On the southern side of the previously mentioned McDonnell ridge near Alice Springs, temperature differences of up to 11C have been recorded by these means (Holton et al., 1990), while extreme temperature rises of up to 25.5C in one hour have occurred with the arrival of the chinook at Pincher Creek, east of the Canadian Rockies (Turner, 1966).

Other remarkable wind and temperature differences have been noted by the author during local Adelaide downslope flow at the ridge-top of the Mt. Lofty Ranges, where windward to leeward of the ridge, the conditions have changed from cold, calm and frosty ... to mild and windy downslope flow over a distance of less than two hundred metres.

Summary

Downslope winds occur in the lee of ranges all over the world. They produce many interesting and unusual meteorological phenomena, including both large temperature rises and large temperature falls, large ridge-top temperature and humidity changes,

wind "roaring" and extreme spatial wind speed differences. These phenomena can be adequately explained by reference to basic hydraulic flow theory.

The two layered structure theoretically necessary for hydraulic flow can be formed by the passage of a shallow cold front across a ridge-line, or by nocturnal cooling of the windward lower atmospheric boundary layer. The latter application would explain the strong nocturnal downslope wind maximum found around the world.

Downslope winds are often found to occur more frequently to the lee of lower ridge-top areas of ranges.

The temperature rise or fall which may be recorded with the commencement of downslope flow at any observation point is directly related to the initial temperature prior to the commencement of the downslope flow at the site.

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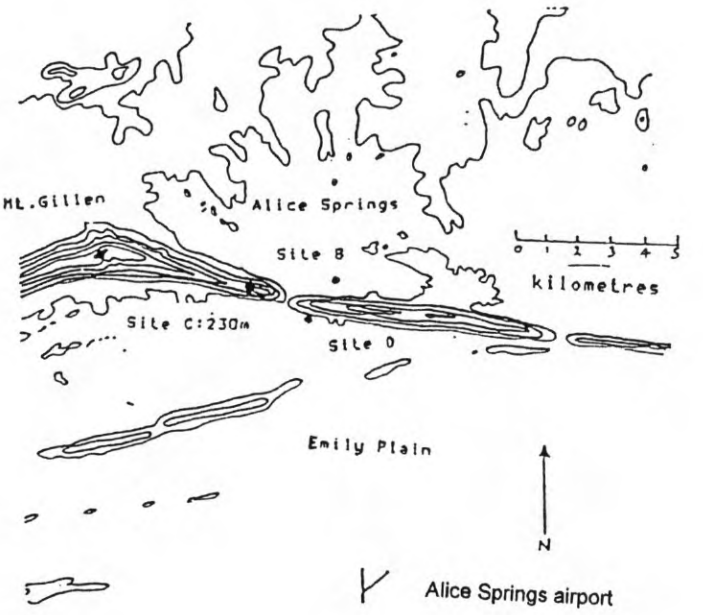

FIGURE 1
LOCATION MAP - ALICE SPRINGS
(Contour spacing at 50m intervals)

FIGURE 2 (a)
SUZUKI AND YABUKI'S LABORATORY EXPERIMENT
The denser saline water (black) begins to stream over the model hill in water (clear) at rest.

FIGURE 2 (b)
As for figure 2 (a) but a short time later. The saline water reaches the model plains, and then "backs up" to form an hydraulic jump.

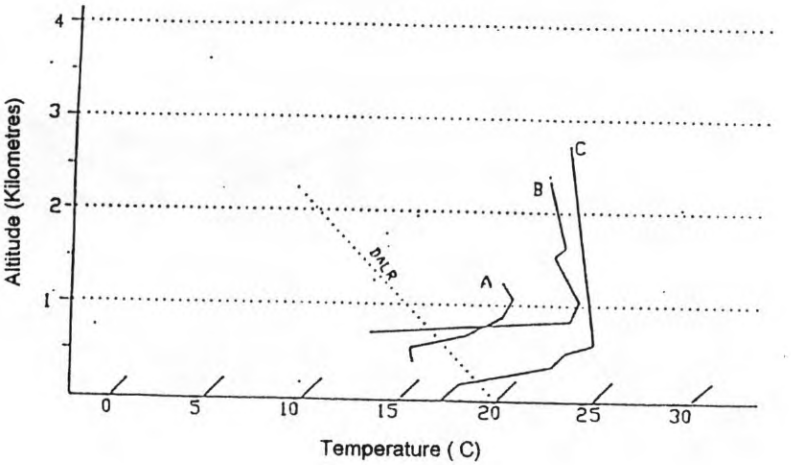

FIGURE 3
WINDWARD - CREST - LEEWARD Low level temperature traces
A = Monarto, 55km windward of Mt Lofty
B = Mount Lofty
C = Adelaide airport, 16km leeward of Mount Lofty
All traces approximately 0001 local, 3rd February 1988

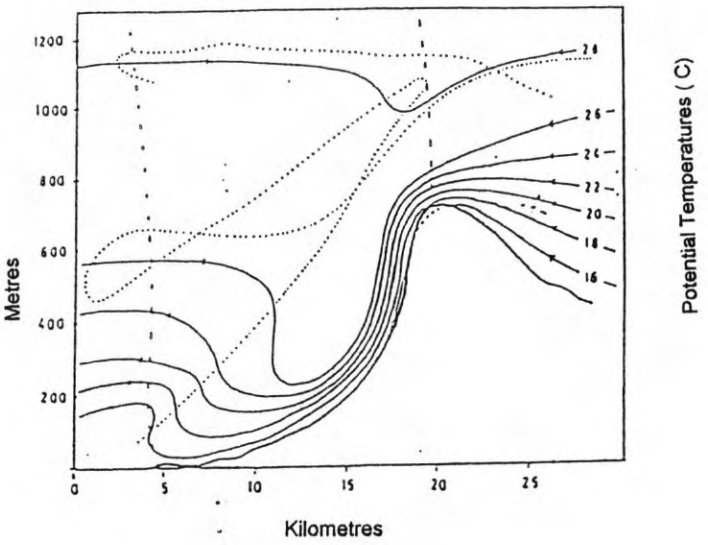

FIGURE 4
Downslope cross-sectional (east-west) analysis through Mount Lofty, at approximately 0001 local, 3rd February 1988. Dashes indicate radiosonde ascents, dots indicate motorised glider observational tracks. (After Grace, 1990)

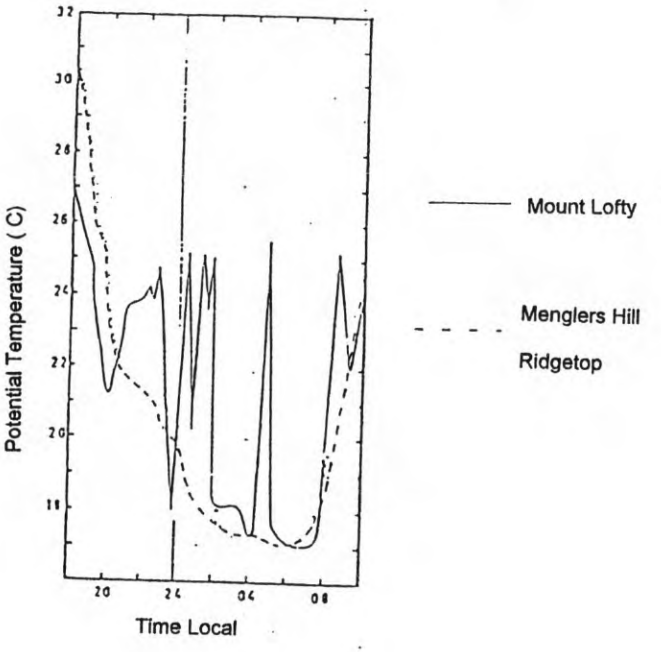

FIGURE 5
Large and rapid temperature oscillations - Mount Lofty summit on 15th to 16th February 1989. Mount Lofty = 736m. Menglers Hill = 510m.

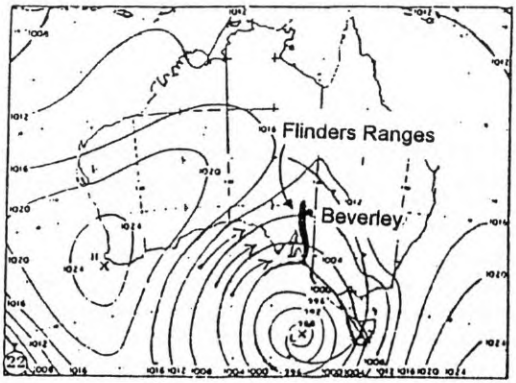

FIGURE 6
Surface synoptic map for downslope wind situation at Beverley, North Flinders Ranges, South Australia. (0900 local, 22nd June 1981)

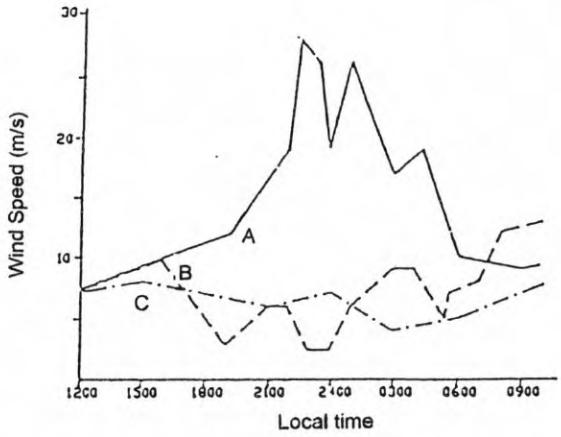

FIGURE 7
Mean wind speeds: Downslope flow at Beverley, North Flinders Ranges, South Australia, on 22nd and 23rd June 1981
A = Paralana at lee base of ranges, lee descent of 900m
B = South Pipeline, 19km downstream of Paralana
C = Woomera, approximately 180 km to windward of Paralana

Rainfall Distribution in the Mitcham Council District

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In my research into variations in domestic gardens it was expected that local variations in precipitation might exert influences on the plant genera and species being successfully cultivated in different localities within the study area.

An initial approach was made to the Australian Bureau of Meteorology (ABM) for records, but it was found that minimal data are available at the local level, the only current official recording stations operating in the study area being the Waite Institute (Glen Osmond), Clapham, Kalyra (Belair) and the Woods and Forests Nursery (Belair National Park). Microfiche records produced by the ABM (1989) were used to locate further stations. Where records had been kept from 1901-1950 data were then used to prepare the map, showing rainfall for the local area, based on an enlargement of the map published in the Report on Metropolitan Adelaide (1962, p21). Official rainfall data were supplemented by unofficial rainfall records to interpolate data for as many stations as possible within the Mitcham Council area. Isohyets from non-official data sources were then superimposed on to the base map.

Non Official rainfall records

Various institutions likely to have maintained precipitation records were approached, namely Flinders University, Wittunga Botanic Gardens, the Department of Agriculture, the Country Fire Service, post offices and local schools. Then long term local residents were contacted, particularly those whose families had past or current agricultural and horticultural associations with the district, and were likely to have kept private records. Finally, the local newspaper (Messenger Press) was approached to print a request for help, and notices were placed in central places such as local post offices, Council chambers and Libraries. As a result of this search a further 102 sets of privately recorded rainfall data were located.

Sufficient sets of data (40) had been maintained for over fifteen years to enable some correlation with official records. Twenty of these sets of records had been maintained continuously for 20 or more years. A further eighteen stations had records for 10-14 years. Although statistical tests have not been applied to locate variability or errors, the general pattern of isohyets produced from these private records approximates the official map.

The situations of backyard rain gauges, plotted on Map 1, are dispersed randomly over the entire area, with the only discontinuity apparent in Edwardstown, a suburb which contains predominantly industrial establishments and low cost rental residential accommodation. Most gauges were carefully sited to avoid undue influence of trees and buildings, or had been relocated as trees and shrubs had grown.

Problems identified which would have required consideration in testing for reliability and variability include:

(a) length of recording period
(b) establishment of a common period of 10 years or more
(c) use of different types of recording apparatus
(d) reliability of individual recorders
(e) time of day when recordings were read
(f) location of gauges to avoid 'rain shadow' effect of trees, buildings, fences etc.
(g) missing data during householder absences
(h) changes of measurement from Imperial to Metric (generally the standard conversion used was a simplified formula of 1 point = 25mm, rather than 1 point = 25.4mm)

Average annual rainfall figures have been calculated and plotted on Map 1 for stations with:

(a) 20 years or more of continuous recording
(b) 15-19 years of continuous recording

For those stations where records have been kept for a shorter period (less than ten years) but overlap in time with the longer records there appears some positive association with official records. The period 1980-1989 included one of the wettest years (1986) and one of the driest years (1982) on record for Adelaide and the average for this period generally correlates closely with long term averages. Records suggest that in the past decade rainfall has been above average in the hills area, and below average along the foothills, while records kept on the plains indicates little variation from the long term mean.

The presence of many rain gauges in the study area, if representative of the rest of the Metropolitan area, may suggest that gardeners are coming to accept the limitations and variability of Adelaide's climate, particularly with respect to rainfall. Several householders indicated that they used their records as a guide to irrigation requirements for their gardens, particularly for the lawns.

The influence of topography on rainfall

The isohyets generally follow the contour lines, shown on Map 2, indicating an association between topography and precipitation. Definite rainfall gradients are apparent from west to east, and north to south, as the topography rises from the relatively flat plains, up the steep escarpment to the first line of ridges, a marked increase in mean rainfall occurring along the escarpment. The lowest recording occurs in the north west corner (Clarence Gardens Bowling Club) 499mm, and the highest in the south east corner (Cherry Gardens PO) 933mm.

Isohyets drawn from the unofficial local records more closely follow topographic features associated with the drainage basins of the major creeks marked on Map 2. Deep erosional gullies account for the variation in rainfall recorded over a relatively small distance which is not recognised on the larger scale of the official source map. Inconsistencies in the distribution of rainfall recorded in the hills area occur where the

topography varies considerably in altitude, aspect and degree of slope. These local anomalies were supported by observations of residents who had noted marked differences in the occurrence of rainfall within even a street or two, when compared with recordings of nearby friends.

Although the Mount Lofty Ranges are low in elevation by world standards (highest point, Mt Lofty is 720m), there is sufficient altitude to produce an observable orographic effect. Schwerdtfeger (1976, p.76) explains that orographic uplift results in the formation of an amplified wave in the passing airstream, possibly twice the height of the physical obstacle, producing rain to benefit the Adelaide Plains and the Ranges for about eight months of the year. This causes Adelaide to experience a climate which is anomalous when compared with other parts of the State at the same latitude and location, such as Yorke Peninsula.

Coote and Cornish (1958 p.5)) believe that Adelaide receives negligible amounts of purely orographic rain, but concede that topography intensifies the precipitation derived from frontal uplift which occurs predominantly during the winter months. Their series of twelve maps shows the geographical distribution of monthly isohyets for the Adelaide Plains and Southern Mount Lofty Ranges. Sea level isohyets are superimposed to illustrate the influence of altitude against the normal decrease in rainfall as distance from the coast increases, their evidence reaffirming that isohyets closely follow the contours.

Stenhouse and Cornish (1958) describe Adelaide's climate as one marked by strong incidence of winter rainfall associated with cold fronts, oriented NW-SE, their activity being intensified by a similar alignment of the ranges. Summer surface heating of the plains and the 'heat island' effect of the urban area may further contribute to convectional uplift.

There is also some evidence from records to suggest that the plains and foothills frequently record higher falls of rain in the summer months than occur further into the hills, probably due to thunderstorm activity and associated convectional uplift. However, once the more regular winter rainfall regime becomes established, the pattern reverses, with the higher altitude stations consistently recording greater amounts of rainfall from June to September than the lower areas. This observation is supported by Schwerdtfeger (1976).

Incidence of rainfall is much more uniform in the winter months throughout the region, while conversely summer rainfall is much more variable within even a limited area.
The distinct rainshadow effect on the hibernal lee of the Ranges is, to some extent, observable in local rainfall recordings, particularly in Belair, Glenalta and Coromandel Valley where a marked decrease has been noted north-east of the ridges, i.e., on properties which have a north-eastern aspect.

Absence of cloud cover in summer and high daytime temperatures have contributed to Adelaide having an approximate evaporation rate of 200mm in January, producing an extreme soil moisture deficiency for the summer period and into autumn (ABM). It

can be assumed that the evaporation levels for the study area would not vary greatly from this amount.

The rainfall distribution pattern, its reliability and deficiencies constitutes one of the most important natural influences on plant selection and garden practices in any given area.

The effect of vegetation on rainfall

Schwerdtfeger (1976, p.78) mentions a little known precipitation mechanism which involves the capture of cloud droplets by tall trees on occasions when normal thermodynamic processes are inadequate to cause precipitation. Short term augmentation of effective rainfall may give considerable benefit to vegetation, both indigenous and exotic, in the higher parts of the Ranges in summer. This would certainly contribute to the successful cultivation of exotic cool temperate plants such as azaleas, camellias and hydrangeas, and deciduous trees in the Mount Lofty Ranges, while artificial environments are needed for such species to survive in the warmer, drier Plains suburbs. Adelaide's climate, although generally comparable with non-alpine central Europe, experiences a higher summer evaporation rate and strong seasonal polarization of rainfall which makes it impossible to grow shallow rooted plants on the Plains without irrigation for at least four months of the year (Schwerdtfeger (1976, p.78).

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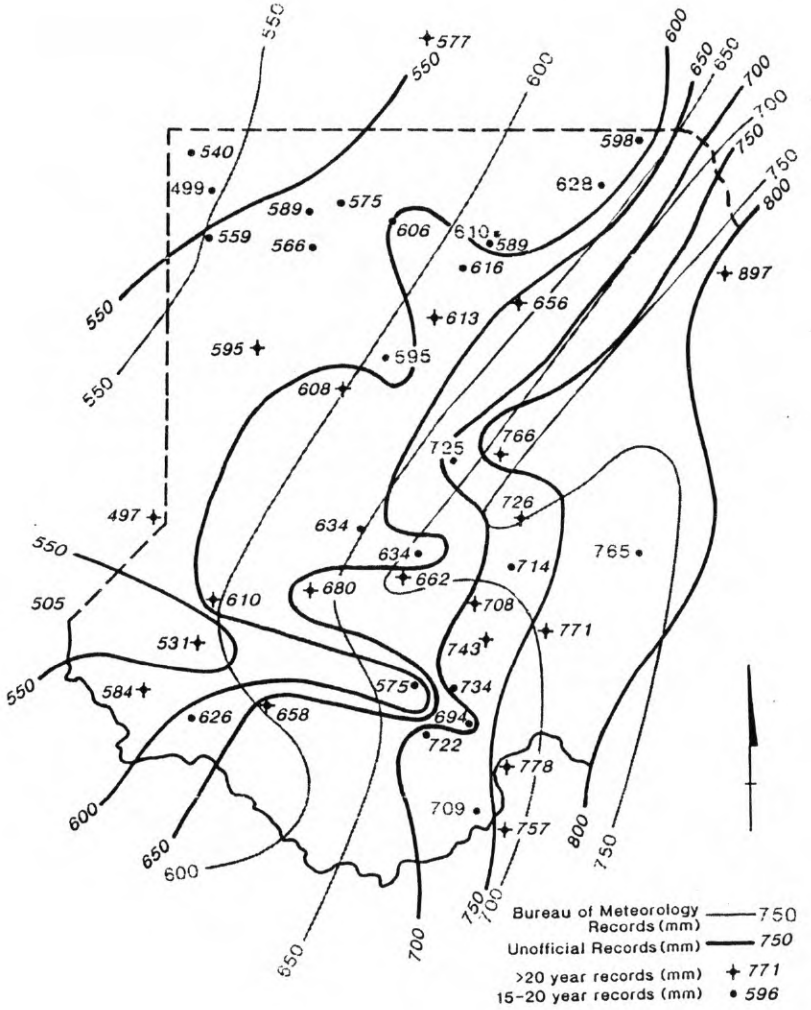
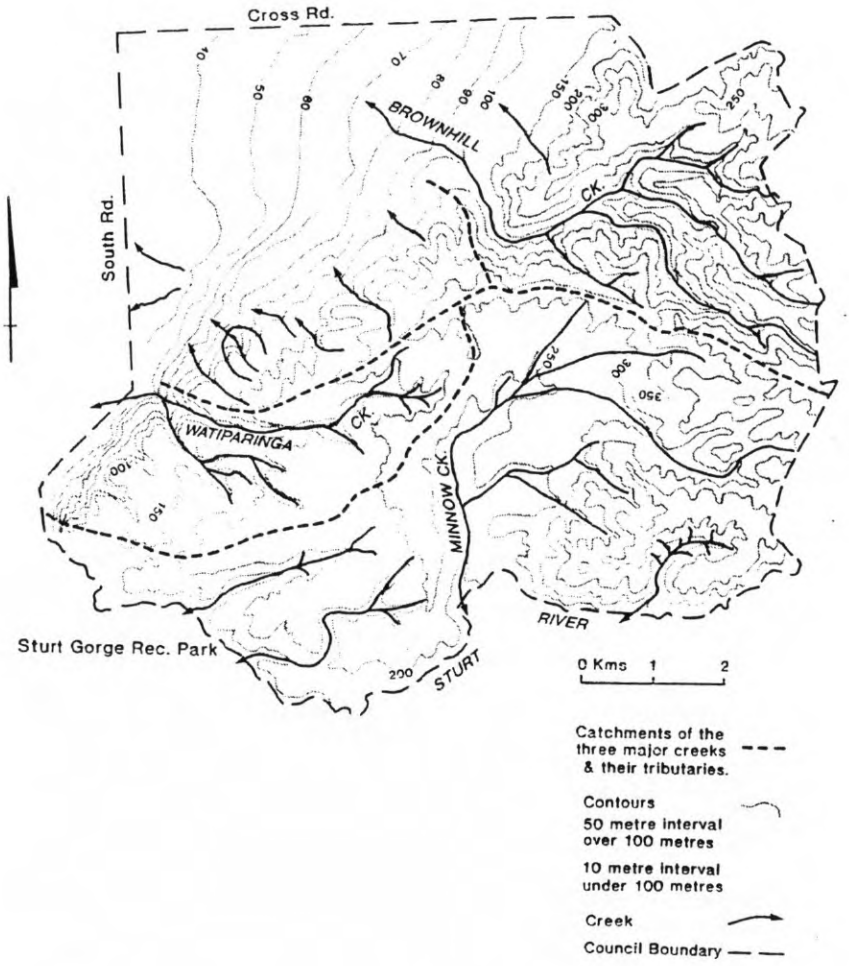


MAP 1
RAINFALL OF THE STUDY AREA
Official and unofficial data



MAP 2
TOPOGRAPHY AND DRAINAGE
OF THE STUDY AREA
(Mitcham Open Space Survey 1982)

Some Reflections on Antarctic Meteorology

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January 1773
"66 S - On 17th in the forenoon we cross'd The Antarctic or South Polar Circle which never was done before and sailing still south in the evening we saw a field of pack'd ice and a number of (ice) islands, Whales, Penguins, Snow Birds and a bird we had never seen before"

Thus was described man's first day in Antarctic regions in HMS Resolution under the command of Captain James Cook. The writer was Richard Pickersgill, 3rd Lieutenant, described by a contemporary as "a good officer and astronomer but liking ye grog". Many such men have followed the lure of the south, and in the subsequent 220 years the geography, geophysics and biology of the Antarctic have gradually been explored. New technology in the fields of transport, measurement and communications has been exploited and the modern Antarctic expedition operates in a way far removed from the "heroic era" of the 19th and early 20th centuries. Despite this, however, the violent elemental forces of atmosphere, ice, and ocean still challenge human invasion of this last wilderness as well as the understanding of the scientific processes which control the observed phenomena.

From the outset of scientific investigation of Antarctica its meteorology has been an area of prime interest. The first winter meteorological observations were taken aboard the "Belgica" in the South pacific sector in 1898, and in 1899-1901 the British "Southern Cross" expedition wintered at Cape Adare at the north western tip of the Ross Sea where Louis Bernacchi, a young Tasmanian, was responsible for the first meteorological and magnetic observations on the continent. The classic expeditions of Amundsen, Shackleton, Scott and Mawson were carried out in the years from the turn of the century to the beginning of World War 1 and produced extensive meteorological data series. These expeditions also saw the beginnings of the first attempts to understand the atmospheric physics of Antarctica with the work of Simpson, who served with Scott and later became Director of the British Meteorological Office, and Mawson who measured and attempted to explain the phenomenal coastal winds of Commonwealth Bay. During the inter-war period, Antarctica was left to its immemorial isolation except for the summer expeditions of Mawson in 1921-31 (the so-called BANZARE Expeditions) and the important introduction of improved aircraft notably by Byrd and Wilkins and their use for exploration of parts of the coast and interior of the continent. Meteorological work at this time was however very limited, though in New Zealand, Kidson was beginning to work on the consolidated data of the early expeditions, introducing the then new frontal analysis techniques to explain the observations - work which was not published until 1947.

At the end of the Second World War interest was again revived in Antarctica, initially by the massive US Navy Operation Highjump and subsequently by the establishment of the French base of Port Martin in Adelie Land in 1950 and the Australian station at Mawson in 1954. This followed the earlier ANARE (Australian National Antarctic Research Expeditions) bases at Macquarie Island and Heard Island set up in 1948. All these stations were equipped as upper air meteorological observatories and Mawson holds the record for the longest meteorological record at any single site in Antarctica. On the other side of the continent the Norwegian British Swedish Expedition operated at Maudheim in 1950 in the Weddell Sea sector and produced high quality meteorological and glaciological results. As well, the Falkland Islands Dependency Survey (FIDS), later British Antarctic Survey (BAS), maintained bases in the Antarctic Peninsula region.

A new spirit of international scientific cooperation (albeit with elements of political and ideological rivalry) was abroad in the mid 1950s and led to the development of the Internatinal Geophysical Year (IGY) of 1957-58 when Antarctica was virtually invaded by many national scientific expeditions. Quite suddenly the continent acquired a meteorological station network of surface and upper air observations ringing the coast of East Antarctica, the Weddell Sea and Antarctic Peninsula and extending into the interior with the establishment of the Amundsen-Scott base at the South Pole by the United States and Vostok on the high East Antarctic plateau by the Soviet Union.

The observations from this network were initially collected by a so-called "Antarctic Weather Central" established at the United States' base Little America on the Ross Ice Shelf where an international team of meteorologists attempted to produce high latitude Southern Hemisphere analyses and to understand the meteorology of the Antarctic. This work benefited from the earlier work of Kidson in New Zealand, Gibbs, Langford and others in Australia, the extensive work carried out by the South African Weather Bureau largely by Taaljard and Van Loon and by the Massachusetts Institute of Technology program of Southern Hemisphere meteorology studies of the early 1950s.

At the end of the IGY the Southern Hemisphere analysis function was transferred to the "International Antarctic Analysis Centre" (IAAC) which was set up in Melbourne and internationally staffed. The Centre later concentrated on research and its analysis function was taken over by the Bureau of Meteorology in 1968. By the late 1960s satellite imagery coverage of the hemisphere was becoming routinely available and the development of numerical analysis techniques was adding greater objectivity to routine analysis and subsequent research activities. This work has continued and the modern global analysis systems developed in various parts of the world, notably the US, the UK and Australia, include Antarctica in the analysis domain. Development of satellite-borne atmospheric sounding systems in the 1970s and '80s has improved the data coverage over the oceans as have the data from the fleet of ocean buoys deployed originally for the so-called FGGE experiment of 1978-79 and subsequently maintained.

The 1970s and '80s also saw an increasing interest in atmospheric chemistry and in the study of the background levels and transport of trace constituents and pollutants of the

atmosphere. For this work , Antarctica as the location of the "cleanest" air on the planet became an area of particular study and sampling programs and extensive laboratory facilities were established in various parts of the continent. This work culminated in the so-called springtime stratospheric "Ozone Hole" over Antarctica in the mid 1980s and the establishment of its cause as man-made chlorofluorocarbons (CFCs). Subsequently, peak activity occurred in the international conservation movement with its overall concerns about the increase of UV levels at the earth's surface and more generally the perceived threat to the future climate of the earth resulting from increases in the "greenhouse" gases (principally carbon dioxide). This concern was readily taken up by activists and later by political systems throughout the world where various agendas (not always related to conservation) were actively pursued and continue to present a hallenge to international diplomacy.

On another front in Antarctia the conservation movement saw an opportunity to win what proved to be a relatively easy battle in translating an international minerals agreement which had been negotiated over the previous decade into an international agreement to ban mining activity on the continent, initially for 50 years but probably permanently. This is expressed in terms of the "Madrid Protocol" to the Antarctic Treaty of 1991. The move to obtain agreement to such a protocol was led by Australia and France and was assisted by the fact that there had been no actively expressed intention of carrying out mining activity in Antarctica in the foredeeable future as the absence of known extraordinarily rich deposits and the formidable logistic and economic problems were not calculated to attract a high level of international investment.

However the Madrid Protocol and the continuing attention of conservationists towards the minutiae of the effects of human habitation in Antarctica have gradually preoccupied the attention of Antarctic Treaty Consultative Meetings (ATCM) to the exclusion of scientific research into broader aspects of the global environment which can be studied in Antarctica. There is a perception among a number of working groups of the Scientific Committee for Antarctic Research (SCAR) that the international view of the importance of conventional polar scientific research is being submerged by a wave of poorly conceived concerns based more on emotion than science.

Meteorological networks established initially during the IGY have been essentially maintained with recent growth in the numbers of new generation Automatic Weather Stations (AWS) established by several countries, notably the United States. The AWS network is likely to have an important future expansion as a by-product of a new venture by the United Kingdom, the United States and Japan which are establishing a number of unmanned Antarctic Geospace Observatories on the high plateau to be known as AGONET. These stations will also be equipped with satellite reporting meteorological sensors.

However, the conventional manned upper air network which provides the background to Antarctic meteorology has declined in station numbers, and more importantly, in the frequency of observations. A significant factor is the potential decrease in the enormous effort previously expended by the former Soviet Union in Antarctica. It is further not inconceivable that as a response to this, the level of United States'

expenditure in Antarctica, which, like that of other countries, has been based not only on scientific but also on political concerns, may also be reduced. A notable example of political influence on the Antarctic station network is apparent with the existence of some seven national surface meteorological stations on King George Island in the South Shetlands near the tip of the Antarctic Peninsula in a region easily accessed by non ice-breaking vessels and thus presenting a low level of logistic problems. The data from such stations, while useful if a detailed climatological or other scientific of the island were contemplated, do not provide a significant contribution to the study of the broad aspects of Antarctic meteorology when to the south lies the whole vast region of West Antarctica with very few observations.

As well as their use in global analysis and research, Antarctic observations are also important in the provision of meteorological services for those working on the continent. Such information is required for many purposes including aviation terminal and en-route forecasts, ship routing particularly in pack ice, surface transport, building design and logistic planning. During the latter part of the 1980s the then Soviet Union attempted through the Antarctic Treaty system at ATCMs to get agreement to an international system of areas of responsibility for meteorological services and particularly for marine services. This question was debated at various levels by ATCM, SCAR and WMO (World Meteorological Organisation) but the plan was not taken up as a formal concept. However WMO established standards for forecasting offices in Antarctica, for example, outlining the requirements for good communications, access to all relevant observational data and to the products of appropriate major National Meteorological Centres outside the Antarctic, and availability of on-site high resolution satellite readout facilities from polar orbiting satellites. At present, limited services are provided by a number of forecasting offices notably by McMurdo (USA), Molodezhnaya (Russia), Casey (Australia), Marambio (Argentina), and Frei (Chile). The most recent forecasting office is the Australian Antarctic Meteorological Centre at Casey which was opened in late 1991 and conforms closely to the WMO model.

The provision of meteorological services is likely to become increasingly important. For although some areas of scientific research may be inhibited by the Madrid Protocol it is to be expected that there will be an increasing presence of tourists in at least some areas of the continent, notwithstanding that some controls may be applied under the ATCM. It was recently reported that the United States' base at Palmer in the Antarctic Peneinsula area received no less than 1400 tourists at one summer season with visiting vessels ranging from cruise ships to private yachts for 59 days out of a period of 100 days at the station. This site is not typical of other areas but there is a significant trend towards more tourist activity throughout the Antarctic.

Although many ships of national expeditions are extremely well equipped meteorologically, some having excellent forecasting facilities and direct access to readout of high resolution satellite data, most tourist and private ships are highly vulnerable to meteorological and, in particular, to sea-ice hazards. In recent years several expedition ships have been beset in the pack ice for long periods and others have been crushed and sunk, fortunately with no loss of life. Such incidents, as well as a number of weather-related aircraft losses, indicate that there is a growing need for reliable meteorological services in Antarctica. Regrettably, a serious accident

involving tourists may well be necessary to convince some governments and some parts of the conservation movement (which, for example oppose the construction of substantial and safe rock-based airstrips almost anywhere on the continent) that the Antarctic "environment" in the broader sense of the word is considerably more dangerous to people than vice versa.

Research into Antarctic meteorology has always attracted only a relatively few scientists though in recent years atmospheric chemists have become more and more active in the analysis of the composition of the Antarctic atmosphere as part of wider global studies. New General Circulation Models (GCMs) are increasingly becoming the tools for investigation of the climate and weather of the polar regions and, in the most recent ones, emphasis is being placed on the development of more realistic descriptions of the complicated ocean, atmosphere and sea ice interactions. Mesoscale models are now able to reproduce many observed features of the katabatic flow over the ice cap which have previously been puzzling. However, much more work is required to perfect our understanding of some of the phenomena and to develop better models. A project recently developed by the SCAR Working Group on the Physics and Chemistry of the Atmosphere (PCA) seeks to increase knowledge of model performance in the Antarctic by conducting an experiment to be known as FROST - First Regional Observing Study of the Troposphere - with several extensive observing periods planned for 1994-95 with subsequent analysis and research.

Antarctic meteorological is generally not well resourced in any country and as yet lacks the support of a constituency of service users, which as for example in the case of tropical meteorology, is able to exert pressure for more services and supporting research. Further, in many countries the meteorological activities of national expeditions are controlled not by the National Meteorological Service but by expedition managers or directors of research bodies who are often indifferent to the requirements of operational meteorology which provides the basic information on which research projects in many disciplines depend.

Those who are most vocal in the interests of the Antarctic are the conservationists who wish to protect the perceived fragility of its environment from the actions of people. However in view of the enormous natural changes which Antarctica has seen in its climate and environment in the past two million years during which time ice caps have grown, combined and receded; open sea channels across the region have opened and closed; and forests have flourished and perished in the Trans-Antarctic mountains, it is likely that Antarctica will require little external help to pursue its destiny.

What would Richard Pickersgill, were he reincarnated, make of all the developments in Antarctica since that summer morning in 1773 when the Resolution crossed the Antarctic Circle for the first time? One suspects that he might bemusedly call for another grog.

1993 in Antactica

Tony Vaughan

Tony spoke to AMETA in Adelaide on Monday 20 June 1994, giving his personal thoughts and impressions of his year at Casey in Antarctica.

The secretary of the Association, John Pethick, transcribed the following from a recording of the meeting. As John says, "Tony has worked for the Bureau for many years and is known as an informative, witty and amusing speaker. His reputation was further enhanced by this speech. I quote from his talk which was recorded, with minimal editing. Some of the aspects he covered included:

The family left behind
Work at Casey
Leisure and recreation down south
Personal interaction - joys and problems
Homecoming - retribalising"

Good evening Ladies and Gentlemen, and a special welcome to Mark Spooner, who was a radio tech at Casey with me. Tonight I am going to give you a personal opinion of my year in Antarctica. Most of us have seen the photos and documentaries but I would like to explain what life is like for an ordinary bloke down on the ice. My background is as an Observer with the Bureau for almost 30 years with visits to the Cocos and Solomon Islands, Darwin, Tasmania and Giles. My last trip to Giles was in late 1991 to early 1992. I took leave and came back to work in Adelaide and I had a week to apply for the Antarctic. So in that one week I had to convince, organise, talk, cajole my family into allowing me to go down to the ice. My wife being a lovely old fashioned lady said that if that's what you want to do then go and do it. I sent in the application and heard nothing more for several weeks, and then the news came that I was to have an interview, and I was selected.

Then the fun started - with medical and psychological testing. Subject to these results I was to be the Meteorological Officer in Charge at Casey. Casey is due south of Perth at a latitude of 66 degrees. The medical is thorough and quite undignified. The psychological test was at Keswick Army Barracks. It's a curious business. You go in and are faced with 100 questions on a sheet with yes/no/don't know answers. First thoughts you are thinking is what are are looking for. At the conclusion of this you think, "I'm finished", but then here's another sheet of 100 questions. Then a third set. By now this is the real you coming out, and this is what they want. Some of the questions were unusual, like "Would you rather read a poetry book or hold a loaded rifle?" Finally a ten minute interview of questions like, "Is your marriage breaking up?", "How much money do you owe?", or "Who are you running away from?"

My reasons were,
1. The financial inducement,
2. This was one year of my life when I could leave home without affecting my daughter's education , and
3. I have been most places with the Weather Bureau, but never down south.

In September 1992, I was sent to Antarctic Division in Hobart for training. Consider that once you are in Antarctica, there are no police, fire brigades, hospitals or emergency services, so we have to provide our own. Each person undertakes some sort of specialised training. Mine was fire fighting, which we all did. I'm also qualified to drive a fork lift truck. More importantly, 4 went to the Royal Hobart hospital , 2 trained as theatre nurses, 2 as anaesthetists, giving the doctor capable assistance. Other courses include small boats and electronics. Everybody has to be trained in the various aspects of station life. To bring all of the station personnel together so that they could bond, gel and become a unit, the Antarctic Division sent us all up to a place in the heartlands of Tasmania called Bronte Park, where we did adventure type training, camping out under the stars, abseiling and various pursuits designed to put us under a wee bit of pressure, so we could react and interact, and see how we could cope. This was quite an eye opener, strangers like you and me; we're going to live together for 13 months down the ice. There are two ladies and 17 men! How are we all going to get on together? So we had station meetings and I got myself in a real bind about foul language. To my mind you do not use certain words in front of ladies. Half way through the year one of the women was using the same language I had said shouldn't be used in front of her! Once in Bronte Park we had to decide who was going to perform what jobs. Such things as who was going to be the chief brewer, music director, station photographer, amenities officer etc. People who were keen on a particular subject were selected to perform these functions, such as photography. (Our cook Marnie was chosen.) This was a very important job because that was the official record of our year in Antarctica. Cameras and film were supplied and she took about 3000 shots around the station, at least five of everything, from which two were chosen.

We have done our training and we are all set to go and someone says duty free. Get some grog, perhaps a computer, TV sets, cameras etc. There is nothing down there to spend money on so we bought a pile of duty free gear, which was delivered to the ship before it sailed.

My personal farewell had mixed emotions. My wife came down 3 or 4 days previously and I had great difficulty coming to grips with the fact that I wasn't going to see her, wasn't going to hold her, wasn't going to smell her. It really sheeted home to me what a decision I had made! I could back out, I still had time not to go. But I thought - no, this is it, and Jan said we'd survive. So on the morning of the sailing there is a jazz band on the wharf and ribbons from the ship to the wharf. We go aboard, find our cabins and there is this eerie sort of feeling. My wife is on the wharf, I'm on the ship, we have this telepathic bond between us, knowing as the ship moves away from the wharf, this sort of mental elastic band has to break sooner or later. The ship leaves with lots of waving and cheering and you're standing on the stern still waving. All you can see is this little minute figure on the end of the wharf and she's

still waving. Of course its not just me but everybody is doing it. We sail down the Derwent and that sort of closes the first chapter.

We are heading south on the Icebird (a German cargo ship), with a passenger module on the forward deck, which holds about 90 passengers. When we head south in summertime it is not just the winterers, but the summer crew as well. Scientists, builders, relief staff, all cooped up on this relatively small boat. How many of you have been seasick? Some blokes were crook before we left the wharf. They thought they would be crook and they were. We didn't see some of them till we reached the pack ice. Go down to the saloon for something to eat and see some of the less well people. But after a while people began to enjoy the awkward movement of the ship and the brisk clean air - sea life in the form of birds, dolphins, albatrosses, sooty terns. And then we hit the Antarctic convergence zone where the relatively warm water meets the cold water. A definite change where the birds disappear, and there's very little until the first iceberg is on the radar about 40 miles away. We eventually see it on the horizon, so we give it a dose of kodak poisoning, everyone clicking away. (What was amusing was that at Casey there were 30 or 40 icebergs visible all year around.) Others follow then into the pack ice, the sea flattens due to the weight of the ice. It is relatively easy going at first, but after a while we can't go any further as Icebird is not an ice breaker. It is an ice strengthened ship. We force our way up onto the ice and the weight of the ship breaks or parts the ice. Sometimes we stop, so the helicopters are brought out and the voyage leader and the skipper goes up with the pilot to look for leads in the pack ice and slowly but surely we keep heading towards Casey.

We got to a position about 90 miles off the mainland when it was decided that we would fly off. This was tremendously exciting, and I was scared. Preparations included wearing an immersion suit with overboots with only hands and neck visible. Common sense prevailed and I relaxed. It was exhilarating, and away we went. Flat pack ice with icebergs sticking out. 30 minutes later we saw Casey. In we went right in front of the red shed (the main accommodation block). It was unreal. Were we really there? We were overwhelmed with kindness by the station crew. I was a total stranger intruding on their cocoon and was instantly accepted. Not much snow, it was summer and the thaw had started. Another impression was of the massive strength of the buildings, steel pillars and girders and panels, home for the next 13 months. The old crew had been there for about 13 months and there were only two days to do the changeover. It was hectic. I was relieving the OIC of the Met Office and she said, "There's your room, put your gear in there." This is it, handover/takeover. I had only been ashore for about 10 minutes and into it. The important thing is to check that all the stores that are on the stocktake are present, because if anything is missing there are no deliveries once the ship has gone.

Station routine, no maids or cleaners. There are two cooks in summer, one in winter so we all have to help. The most arduous task is "slushy" or kitchen hand. You work from Sunday to Sunday but on the second Sunday you are promoted to cook as it's Cook's day off. Toward the end of the year you could ask the cook to prepare the meal for you, so you just had to whack it in the oven. Security is mainly staying alive, so each night someone was rostered on night watch which entailed patrolling the station

at regular intervals and reading the gauges in the powerhouse to ensure that the diesels were producing power, and all the systems were working.
In fine weather - OK - but in a blizzard you just checked the powerhouse. It was too dangerous to try to check other areas of the station. Other duties included checking the water and sewerage systems; make sure all buildings are shut and keep a fire watch. As you can appreciate, fire is the one thing you do not want in Antarctica. There have been a couple of fires at different stations. Fire fighting equipment is top class but the fire appliance has a very limited supply of unfrozen water. If there is a fire that can't be controlled then you just vacate the building and let it burn after saving what you can. Fire and power are the critical things to watch out for on the night shift.

Summertime was hectic: all the scientists trying to complete their program. There is plenty of light, sun up at about 3:30 am, down at 11 pm. Helicopters would fly people into their areas early and leave them there until pick-up a few days later. Met people have to do their own work. Then there is resupply, or someone else who needs a hand. We all gel together to get the program finished before the ship takes summer expeditioners away before winter sets in. In summer there are about 60 to 70 people on station but in winter about 20, so all these extra people means there are few quiet places to hide. Its 3 deep at the bar at night.

Talking about the bar, the beer allowance is one carton a month. Antarctic Division supplies this for you. It can be Guinness, beer, cider and as much soft drink as you want. In their wisdom they also supply Coopers home brew and equipment. We make our own brew, two 200 litre drums. A few weeks later it is bottled, about 400 bottles filled, sugared and capped, by a group of about 12 people. When you open a bottle you soon find out which had 2 teaspoons of sugar added. The home brewing was an excellent way of bringing us all together. When it came time to drink it, it was a joint effort, and took on a great significance because it was something we had done ourselves. Recreational things included the cinema called the Odeon. 150 movies, and on Wednesdays and Sundays the kitchen slushy chooses the movie. But the caveat was that you could not repeat a movie that had been shown already. Movie night was 8 pm, bring a drink and whoever was the projectionist would try to keep some sense of decorum by flashing the torch on noisy imbibers. Some movies were good but some were garbage, like Ronald Reagan's last film. Movies were a top part of station entertainment. We had a video room & 300 videos, a library with over 3000 novels & magazines on many subjects, games, jigsaws, puzzles, sports like table tennis, snooker, billiards, darts, cards etc.

Outside there was skiing, running, walking, skating. About 20 to 30 sets of skis and boots, but only 3 sets of ice skates so if your foot didn't fit the ice skating boot you didn't skate. Summertime finished and the summer crew had to go back. Our last chance to write letters, cards and all of the things that have to be done. The departing summer crew gets pelted with flour bombs, custard powder etc. When they had gone we all congregated in the mess and had our first station meeting, of we the Casey winter crew, and this was a red letter day. Station meetings were called regularly by the station leader to nut out problems, gain a consensus of what we should do, and he would tell us what he thought we might do.

Once we were by ourselves, and all the red tape was gone, the old Churchillian theory "Rules are for the obedience of fools, and the guidance of wise men." What do we want to do with our winter? How do we want to run Casey? Obviously safety is paramount. There is no compromise. Sea ice travel, fire regulations, smoking in buildings, mealtime sittings, formal dinners, recreation, cleaning are decided. Traditionally station cleaning was Saturday afternoon. You finished your normal work, and you were rostered on for cleaning the mess, or breaking empty beer bottles, doing the toilets, cleaning the outside station. Everybody took their turn. We decided on our program for a trial basis of six weeks and then fine tune it if we found out that things weren't quite working to plan. We did that, we got everything well organised and then we thought right, - time to enjoy ourselves.

Cocktail night, fancy dress night, Mexican night. This was a good night. The electrician was a bit of a tequila enthusiast, and out of the kindness of his heart he said, "Right, there's four bottles of tequila." We all dressed up. Cook excelled herself, with lots of hot spicy food which makes you very uncomfortable next morning. Japanese night, - our station leader had been to Japan teaching English, and he was very keen to have some Japanese influence there. So one night we sat on cushions in the recreation area with our chopsticks and cook prepared a Japanese meal. It was quite extraordinary thinking of all the things we could have done, but this one came out of the blue. The progressive dinner was memorable. It was to have been at various huts around the station, but the weather set in and we couldn't leave the main building. So it was decided to have a different course at each part of the building, finishing up with one course, where the man-hole (person-hole) cover was lifted from the floor, and we got under the main building and served it there. Mad! But these are the daft things you do. Whilst we were enjoying ourselves we were still working very hard, especially in the met section!

We had a wee bit of trouble with snow. The way the balloon shed was placed the back of the shed was to the east, and the wind comes from the east. The balloon shed doors are on the western side, and when the wind blows there is this vacuum effect, and all the snow builds up to about here (about six feet). How are we going to get the balloon out? So we coerce a couple of the troops with a big 950 shovel and they clear close to the building. But they can't come too close because if they damage the skin of the building we are in trouble. OK, Tony, there you go. It's called a D1, a shiny thing with a wooden handle! I'd love a dollar for every shovel full of snow I removed - I'd be a wealthy man. But this was just one of the things that had to be done to perform the meteorological program. You do this every day for about three months. You get bloody sick of it, I'm telling you. First you had to scoop a path from the met office to the balloon shed to get to it. But that's by the by. The mechanics had the same sort of problems trying to get down to the workshop. And when there's a blizzard you just can't get there. We experienced wind speeds of 150-160 almost 200 km/hr in some of the blizzards. Visibility about 1-2 metres.

We set up blizzard lines of one inch rope. You grab the rope and direct your way from building to building. It's the only way you know where you are going. From the met office to the red shed (main building) was about 150 metres. With the wind at your back its about 10 seconds, if you can stop at the met office. Against the wind it could take anything up to five minutes. It sounds pretty stupid to say it took 5 minutes

to walk 150 metres. I tell you what, - if you don't know where you're going and you can't see where you're going, and you've just got this bit of rope, it's a funny feeling when you have got no reference points. All you can see is white; there's no definition. In your mind, it just doesn't register. Apart from knowing that the wind's coming this way and you should be heading that way, you have no real idea where you are. It's crazy and that's how some people came unstuck in the olden days. Ten/15/30 metres away from shelter and they just didn't get there, - didn't know which way to go.

Right, that's the work part. Everybody does the normal tasks, then we seem to muddle into winter. The 20 hour daylight days slowly, slowly, reduce. On Anzac day in April we had the dawn service at 20 past 10. Towards winter we saw the sun every day but in the middle of winter it just, just came over the horizon and went down again.

That brings me to this time of year which is mid winter, the Antarctic big day. Christmas is big but mid winter is the big day of the year. Tradition has it you have a slap up feed, you drink too much and have a lovely snooze and some of the crew perform the pantomime Cinderella. I don't know why it is Cinderella. We had a fairy queen, ugly sisters with hairy chests, Cinderella and Prince Charming. It was coarse, ribald and good, and we had a ball. The pantomime was followed up by other assorted acts. One of my challenges before leaving home was to take my son's trumpet to Casey and learn to play it again since playing in the school band in 1956. I got on well and had developed a repertoire of five or six songs. After a big meal with plenty of wine, and several ice cold vodkas and I was well primed. I had never drank vodka before and I found that the mouthpiece wouldn't work!! One vodka too many!

The nicest part of mid-winter was the tradition that we sent invitations to many people around the world. Obviously they can't physically come but they can be there in spirit. I invited Philip Adams, Len Evans and Phillip Satchell. Adams and Evans replied in fine fettle. Adams was afraid that in the cold something personal might drop off and Evans wasn't quite sure how cold he could chill his Krug champagne. Other notables invited included Mother Teresa, Ronald Reagan, Joe Cocker, Mick Doohan, the Pope and the Queen Mother who sent a lovely reply. People write and invite anybody. The electrician sent an invite to his friend in Sydney who passed it on to one of the daily papers who printed it in the personal advertisements. We received more than 150 fax messages, and some of them were comical, cartoons, jokes etc wishing us the best. The Tasmanian Arts Council twigged that something was happening and they sent more than 100 faxes of poems, drawings, and stories from various artists and authors. The station doctor hung all of these and we had a wonderful art gallery on mid-winters morning, with a chicken and champagne breakfast whilst looking and reading the messages, dressed in cravats, arty clothing and hats. Apart from light hearted messages we also got lots of personal messages from our loved ones.

Communications included real time telephones, faxes, and electronic mail (the greatest thing ever invented). Just get on the computer and tap and zap, talk to or leave a message for anyone in the world. Most of the mail was faxed in, ie "My darling Tony" etc and drawings from the kiddies, and the communications blokes! Well you could see the smile on their faces as they gave you a message from home.

We had TV, tuned in to a satellite and whatever that satellite broadcast we got, there was no choice. We watched a lot of programs from China and Japan. And the governor of Hong Kong is indelibly impressed on my brain. Every news service included him during the row that was going on between Hong Kong and mainland China in mid 1993. We saw a wonderful marathon race being run in Paris on TV. According to the TV there were two Japanese runners and that was it. But there was a beautiful panorama of Paris which stirred something in me and I have got to go to Paris. Melbourne Cup was the next big day and we had to get dressed. You can appreciate 17 men and 2 women, but 15 girls and 1 bloke turned up! Some of them were quite attractive I can tell you, and it wasn't just because we had been down there all this time! Some fellas come up really well with a bit of lipstick and shaved legs. One of the girls cut her long hair really short, chopped it all off.

That reminds me of an amusing story at one base years ago, when there was an argument between two fellows about who had the most hair. They decided the issue by shaving each others heads bald and weighing the hair. The boys had crazy haircuts, the carpenter was designated hairdresser. As soon as everyone had gone (summer crews), the usual thing was all the hair off, or just a strip of hair in the middle (mohican style) One chap had his wife's name (Teresa) shaved on the back of his head. The doctor had a checkerboard. It looked crazy. Silly daft things that you do! What the hell,! In four months time you are going to have a full head of hair back again.

In summer we had some fellas jumping in the water. When Denton came down he put it on TV. The water temperature was about -1 to -2 degrees and about -12 outside, with a chill factor of about -20. What did we do for recreation? We had field huts, little refuges like a large caravan at various distances from the station, which were ostensibly for scientific research in the summer months, but in winter time for rest and recreation. You'd organise a trip with your mates, stock up with food and drink and just go for the weekend, making sure you told people where and when you were going, and the trip was cleared by the station leader. Cook knew you weren't going to be there for meals, and you took all the emergency gear. The reasons for taking all the emergency rations, clothing etc, is because if the weather does clag in and you're not prepared for it you can be in real strife.

Early on in the piece we had an incident where four of the team had skiied to one of the field huts in pretty good weather and they decided to ski back but didn't quite make it. They got to about two and a half kilometres from the station, a blizzard set in, and they just sought shelter in the rocks. It was quite a traumatic time. What happens is that you can see the blizzard coming and the idea is to put all the warm clothing you can on, and get into this bivvy bag which is like a big tent bag. Get yourself in, then get in the shelter of the rocks and let the blizzard pass. When it has passed, people may come to pick you up or you carry on your journey. This happened about 4:30 in the afternoon, and the blizzard lasted about 8 or 9 hours. The people were there all through the night. At first light the search and rescue team found them, picked them up and brought them back to base. No problems, but that night that they were missing I think every one of us prayed to our respective gods for their safe return. We were all focusing on the missing four who were strangers only three or four months ago. One of them got frostbitten fingers. The doctor fixed him up, but

we had to hand feed him for a while. It really sheeted it home to the rest of us how easy it is to come unstuck down there.

It's after Melbourne Cup, and now we're thinking, it's about time we went home. We've been here too long. Most of the time we got on really well together. There were the odd abrasive moments. During this period when there was a little bit of tension, a couple of groups forming, the young coffee set and the traditional Antarctic veterans, one coffee and wine, the other darts and beer ; just a natural gravitation of personalities. No real clashing, the groups still mixed and intermingled.

Right, the first ship is coming in. Bloody hell, I've got to get some photos. What haven't I done? And its a bit of a panic. I didn't get a photo of that or do this. Of course you can't do it. Slides that you should have taken in the middle of winter you can't take now. It is different. The snow has gone and the light has changed. There was mail from home. Wonder how everyone is getting on. You can talk to them on the phone , but there is something personal and lovely about a handwritten letter.

On the food side of things we did very very well. Our fresh food lasted well. Spud lasted all year; a bit grotty at the end. Oranges lasted 6 or 7 months. All the rest was tinned or frozen. First ship, fresh fruit, fresh milk and letters. So first ship arrived and we just went mad. It came into the harbour at 1 in the morning, and we had had a couple of celebratory drinks, and then we were blowing whistles and letting off flares, whoop,whoop, whoop on the hooters. Everybody acted like little kids. Next day of course, there they are, strangers. Remember when I started, I was a bit apprehensive? Of course we had had a station meeting to talk about the strangers coming in. They are going to be a bit tippy toey. Let's give a lot. They came ashore, and they were such a good group that within a day or two, they were accepted and assimilated into our group. I confess, I was little bit worried that there may have been some "What do you want, that's my seat," feelings. But no, we all stepped back and accommodated them.

Then it was on, the start of the summer programs. Could we help? Of course, in fact we volunteered for a lot of things, providing that we could go up in the helicopter and take some photographs. I don't know if we were unwinding or trying to show off but there were an awful lot of parties, sore heads and embellished stories, but we managed. Then it was <u>our ship</u> coming in. This is what we had been focusing on for the last 6 or 7 weeks. We're going home. We are going to be with our loved ones again. The ship arrives and our replacements arrive. Race, race, race, check supplies, yes there's 52, don't worry about counting. Let's get home! We make sure the new crew is settled in and know what they are doing and it's time for us to leave. We had a couple of discussions and decided we would say goodbye to each other before the first ship got in, while we were still in our little group. So we had our group farewell and then before we actually left to go home we had the official medallion presentation. We get a medallion to say we have actually served at Casey Base. Bit of a lump in the throat and then on to the ship. This was one of those. I find it difficult to tell how I felt. I wanted to go home ... but and yet ... I didn't want to leave moments. This had got to be my home, I had made a lot of good friends, and had a lot of good times, and yet, there was mum and the kids. Obviously, once you are on the ship and the ship goes its goodbye Casey.

The voyage home to me was just a big anticlimax. I couldn't wait to get home. We stopped off at Macquarie Island to off-load their replacement crew then carried on to Hobart. Because we had made such good time, we got into Hobart on the evening of the 27th, when we should have arrived on the morning of the 28th. Mrs Vaughan was leaving Adelaide on the evening of the 27th, staying in Hobart that night and be fresh and spruce at the wharf the next morning. We got there, and I knew this was going to happen. We would come along side; it's a rotten day, drizzling and miserable and all of these people saying welcome and hello, while she's still on the plane. Anyway the next thing is, this taxi comes screaming into the wharf and this grey headed lady starts waving this red scarf. God, it's her! I had told her to wave a red scarf so I could pick her out of the throng at the wharf. Of course they had all gone, but she decided anyway to wave the red scarf. I hopped off onto the wharf for a big fond embrace. I did cry. Tears sprang to my eyes and my wife was sobbing away. And then we look at each other, and then it was like we were courting. You need to rebuild the intimacy between you. It took three or four days before we were really back to where we were before I left. And we were warned that this would happen. In their wisdom the Antarctic Division psychologist is on the ship on the way home and he interviews you and asks if there are any problems about seeing the kids etc. I have been away from home a few times and I'm pretty right or so I thought. They impressed upon us the intimate side of married life, it has got to take time, you haven't been together and you have to patient, which was true. Mum and I got together and had a honeymoon (I suppose our third or fourth) where we spent a lot of time just holding each other, touching, an arm around each other to reinforce the bonds.

Being in Tasmania we had to do the rounds and visit the relatives ... "This is my wife" etc, and still there was this strangeness between us. This was emphasised when we flew back home and I met the family. I was walking on eggshells. There's me in my own home, and there are the children, my daughter, "Hello Dad, how are you going, good to see you," the two boys, "G'day Dad," you know what 20 and 21 year olds are like. I thought I've got to tippy toe softly around here and just ease back into the house. And mum had teed the kids up saying look, "Dad's just got to settle in, give him a chance." Then, "What would you like for breakfast?". Hey this is great, I must go away more often. Five months later and everything is the same as before the trip.

Anyway, to finish off: 1993 in Antarctica is like nothing else I have ever experienced. The strangest, the greatest, the most challenging year of my life, full of emotion, full of satisfaction and a lot of it was full of apprehension all intermingled. Ask me tomorrow, would I do it again? Course I would, but the family won't let me. So that ladies and gentlemen, is Antarctica. But I would just put in a plug for the tourist companies that do send icebreakers and pleasure craft down there. You have to go, you really must, its like nothing else on earth.

A Relationship between Adelaide Rainfall and the Lunar Calendar?

Mrs C O Trenorden
Summertown

Introduction

Generalising, it is obvious that there is an association between rainfall and the time of year in the Adelaide region. In this "Mediterranean" type climatic region, the apparent seasonal march of the sun from the summer solstice with accompanying high solar radiation totals in December and the following months, through the equinox, to the winter solstice with low solar altitudes and radiation in June and back again is accompanied, with a time lag, by a similar cyclic or seasonal change in atmospheric circulation systems over the area.

Our rainfall results from processes occurring within these atmospheric circulation systems and from the interaction of the atmosphere with the earth's surface. Accordingly, Adelaide has its maximum rainfall in winter and its minimum in summer.

The energy the earth receives from the sun, and its variation seasonally and latitudinally is the prime force driving the atmospheric circulation. Apart from the seasonal cycle which affects the solar energy input to a given latitude, it is known that there are other cycles which influence solar output and hence the energy we receive. One such set of influences are sunspot cycles such as the 11 year average cycle and the longer 80 year cycle. There have been many attempts to correlate weather events with sunspot cycles.

What of the moon? Although it is infinitesimally smaller than the sun, its close proximity to the earth means that it does influence terrestrial phenomena. The influence of the moon in producing tides in the seas is well known. There is also a tide in the atmosphere whose cycle corresponds to the diurnal solar cycle and which is evident in barograph traces, especially in the tropics. Although it is very small, a lunar influence also has been observed on the atmospheric tide. This is discussed by Chapman, S., in "Atmospheric tides and Oscillations" pp 510-530 in Malone, T.F. (ed) "Compendium of Meteorology". Amer. Met. Soc., Boston, 1951.

With this in mind then, and despite the dismissal of lunar influence on weather reported by Bauer in the same volume (p819), I thought it might be interesting to examine whether any association existed between rainfall and the lunar month and year at Adelaide.

Our rainfall records are recorded and tabulated according to the normal or Gregorian calendar. Hence, in order to relate rainfall records to the lunar calendar, some manipulation of the calendar we use is necessary.

The lunar calendar

The tropical or solar year on which the Gregorian calendar is based has a duration of 365 days 5hr 48min 45.5 sec, the time for the earth to make one revolution around the sun. To cope with this awkward time of course we have sequences of 3 years of 365days followed by a "leap" year of 366 days.

The synodic or lunar month, or the number of days for the moon to circle the earth, is approximately 29.5 days. This gives 12 lunar months a duration of 354 days, 11 days shorter than the ordinary calendar year, or 12 days shorter than a leap year.

If we consider a lunar month to begin on a new moon, we find that this occurs variously every 29 or 30 days. Each lunar month of course has a full moon, a "perigee" when the moon is closest to the earth in its orbit, and an "apogee" when it is farthest from the earth.

Obviously, to "correlate" the lunar with the solar calendar, extra days must be intercalated or added. Every solar year will have at least 12 full moons or lunar months, but every 3 years or so the solar year will have 13 full moons.

If we consider the lunar month to begin on the new moon, then the full moon occurs either on the 14th, 15th, 16th or 17th day of the lunar month.

In order to formulate a correlated lunar-solar calender, apart from a "normal" calendar, we need the dates of the new moon, which can be found in the Astronomical Almanac. This will also give us the dates of the full moon, apogee, perigee and details of eclipses amongst other things.

Tables 1 and 2 show the Gregorian calendars for 1993 and 1994 respectively "reformatted" or tabulated in the form of the lunarcalendar.

The dates of the full moons (occurring on either the 14th, 15th, 16th or 17th days of the lunar month) are shown in bold.

Note that: in 1993 there was 1 full moon on a 14th day
there were 4 full moons on 15th days
there were 7 full moons on 16th days
and there was 1 full moon on a 17th day,
giving a total of 13 full moons in that year.

By contrast, in 1994 there were 0 full moons on 14th days
there were 6 full moons on 15th days
there were 3 full moons on 16th days
and there were 3 full moons on 17th days,
giving a total of 12 full moons in 1994.

TABLE 1

CORRELATED LUNAR - SOLAR CALENDAR FOR 1993

Days of lunar month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Dec	
01		22F	21$	23T	21W	21F	20$	19M	17T	#16T	#15F	13S	13M	
02		23S	*22M	24W	22T	22S	21M	20T	18W	17F	16S	14$	14T	
03		24$	23T	25T	23F	23$	22T	21W	#19T	18S	17$	15M	15W	
04		25M	24W	26F	24S	24M	23W	#22T	20F	19$	18M	16T	16T	
05		*26T	25T	27S	25$	25T	24T	23F	21S	20M	19T	17W	17F	
06		27W	26F	28$	26M	26W	#25F	24S	22$	21T	20W	18T	18S	
07		28T	27S	29M	27T	27T	26S	25$	23M	22W	21T	19F	19$	
08		29F	28$	30T	28W	28F	27$	26M	24T	23T	22F	20S	20M	
09	1F	30S		1M	31W	29T	29S	28M	27T	25W	24F	23S	21$	21T
10	2S	31$		2T	1T	30F	30$	29T	28W	26T	25S	24$	22M	*22W
11	3$	1M		3W	2F	1S	#31M	30W	29T	27F	26$	25M	23T	23T
12	4M	2T		4T	3S	2$	1T	1T	30F	28S	27M	26T	*24W	24F
13	5T	3W		5F	4$	3M	2W	2F	31S	29$	28T	27W	25T	25S
14	6W	4T		6S	#5M	#4T	3T	3S	1$	30M	29W	*28T	26F	26$
15	7T	5F		7$	6T	5W	4F	4$	2M	31T	30T	29F	27S	27M
16	8F	6S		8M	7W	6T	5S	5M	3T	1W	1F	30S	28$	28T
17	9S	#7$		9T	8T	7F	6$	6T	4W	2T	2S	31$	29M	29W
18	#10$	8M		10W	9F	8S	7M	7W	5T	3F	*3$	1M	30T	30T
19	11M	9T		11T	10S	9$	8T	8T	5F	4S	4M	2T	1W	31F
20	12T	10W		12F	11$	10M	9W	9F	*7S	5$	5T	3W	2T	
21	13W	11T		13S	12M	11T	10T	*10S	8$	6M	6W	4T	3F	
22	14T	12F		14$	13T	12W	11F	11$	9M	7T	7T	5F	4S	
23	15F	13S		15M	14W	13T	*12S	12M	10T	8W	8F	6S	5$	
24	16S	14$		16T	15T	14F	13$	13T	11W	9T	9S	7$	6M	
25	17$	15M		17W	16F	*15S	14M	14W	12T	10F	10$	8M	7T	
26	18M	16T		18T	17S	16$	15T	15T	13F	11S	11M	9T	8W	
27	19T	17W		19F	*18$	17M	16W	16F	14S	12$	12T	10W	9T	
28	20W	18T		20S	19M	18T	17T	17S	15$	13M	13W	11T	#10F	
29	21T	19F		*21$	20T	19W	18F	18$	16M	14T	14T	#12F	11S	
30		20S		22M		20T	19S			15W			12$	

Dates of Full moons in bold, eg. **27T**

Dates of Apogee: *24T

Dates of Perigee: #24T

Flow Pattern of Full Moons for 1993: 1:4:7:1

Total No. of Full Moons	
14th	1
15th	4
16th	7
17th	1

TABLE 2

CORRELATED LUNAR - SOLAR CALENDAR FOR 1994

Days of lunar month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Dec	
01		11T	10T	12S	11M	10T	9T	8F	7$	5M	5W	3T	#2F	
02		12W	11F	13$	*12T	11W	10F	9S	8M	6T	#6T	#4F	3S	
03		13T	12S	14M	13W	12T	11S	10$	9T	7W	7F	5S	4$	
04		14F	13$	*15T	14T	13F	12$	11M	10W	#8T	8S	6$	5M	
05		15S	14M	16W	15F	14S	13M	12T	11T	9F	9$	7M	6T	
06		16$	15T	17T	16S	15$	14T	13W	#12F	10S	10M	8T	7W	
07		17M	*16W	18F	17$	16M	15W	14T	13S	11$	11T	9W	8T	
08		18T	17T	19S	18M	17T	16T	15F	14$	12M	12W	10T	9F	
09		*19W	18F	20$	19T	18W	17F	16S	15M	13T	13T	11F	10S	Total
10		20T	19S	21M	20W	19T	18S	17$	16T	14W	14F	12S	11$	No. of
11		21F	20$	22T	21T	20F	19$	#18M	17W	15T	15S	13$	12M	Full
12		22S	21M	23W	22F	21S	20M	19T	18T	16F	16$	14M	13T	Moons
13		23$	22T	24T	23S	22$	#21T	20W	19F	17S	17M	15T	14W	
14		24M	23W	25F	24$	23M	22W	21T	20S	18$	18T	16W	*15T	14th 0
15		25T	24T	26S	**#25M**	#24T	**23T**	**22F**	**21$**	**19M**	**19W**	17T	16F	15th 6
16		26W	25F	**27$**	26T	**25W**	24F	23S	22M	20T	20T	*18F	17S	16th 3
17		**27T**	**26S**	#28M	27W	26T	25S	24$	23T	21W	21F	19S	**18$**	17th 3
18		28F	#27$	29T	28T	27F	26$	25M	24W	22T	*22S	20$	19M	
19		29S	28M	30W	29F	28S	27M	26T	25T	23F	23$	21M	20T	
20	1S	30$	1T	31T	30S	29$	28T	27W	26F	*24S	24M	22T	21W	
21	2$	#31M	2W	1F	1$	30M	29W	28T	*27S	25$	25T	23W	22T	
22	3M	1T	3T	2S	2M	31T	30T	29F	28$	26M	26W	24T	23F	
23	4T	2W	4F	3$	3T	1W	1F	*30S	29M	27T	27T	25F	24S	
24	5W	3T	5S	5M	4W	2T	2S	31$	30T	28W	28F	26S	25$	
25	#6T	4F	6$	5T	5T	3F	*3$	1M	31W	29T	29S	27$	26M	
26	7F	5S	7M	6W	6F	4S	4M	2T	1T	30F	30$	28M	27T	
27	8S	6$	8T	7T	7S	*5$	5T	3W	2F	1S	31M	29T	28W	
28	9$	7M	9W	8F	8$	6M	6W	4T	3S	2$	1T	30W	29T	
29	10M	8T	10T	9S	*9M	7T	7T	5F	4$	3M	2W	1T	30F	
30		9W	11F	10$		8W		6S		4T			31S	

Dates of Full moons in bold, eg. **27T**

Dates of Apogee: *24T

Dates of Perigee: #24T

Flow Pattern of Full Moons for 1994: -:6:3:3

These groupings, 1:4:7:1 for 1993, and 0:6:3:3 for 1994 are called the "flow-patterns" for those years.

The dates of the perigee and apogee of the moon's orbit are also marked. Note that in some months the perigee or apogee are on or close to the dates of the full moon.

With the Gregorian calendar, for an ordinary year of 365 days, the name of the day on the 1st of January is the same as the name of the day on the 31st of December of the same year. For a leap year, of 366 days, the name day for the 31st of December will be the next name day from the name of the day on the 1st of January of the same year.

Rainfall and the lunar calendar

Using the daily rainfall records for Adelaide for the 60 year period 1911 - 1970, table 3 shows the record of sums of daily totals retabulated by lunar month for each month of the year. The final column shows the annual sums of the daily totals for each day of the lunar month. The values for the 30th day are weighted downwards by the fact that over this period there are only about half as many thirtieth days as any other day in a lunar month.

Figure 1 graphically shows these annual daily totals for each day of a lunar month. Figures 2 and 3 show the same data smoothed by the calculation of three and five day running means respectively. They appear to indicate a tendency for an increase in rainfall towards the end of the month.

Rainfall and flow pattern

Some examples of the "flow patterns" of the 12/13 full moons that can occur in a given calendar year are:

1:3:6:2	-:2:8:2	-:4:6:3	-:5:5:2	-:5:7:-	-:6:6:-
1:4:7:1	-:3:8:1	-:4:7:2	-:5:5:3	-:6:5:2	-:6:3:3
-:2:7:3	-:4:6:2	-:4:8:1	-:5:6:1	-:6:6:1	-:7:3:2

Some patterns are uncommon. For example, since 1839:
The pattern 1:4:7:1 has occurred once; in 1993
-:6:3:3 ; in 1994
The pattern -:6:6:- has occurred twice; in 1913, rf 1815pts
and in 1851, rf 3095pts

On the other hand some patterns are more common. For example, there have been 18 occurrences of the pattern -:5:5:2 since 1839:

1843	(rf 1709pts)	1916	(rf 2816pts)	1951	(rf 2544pts)
1845	(1882)	1924	(2344)	1956	(2724)
1854	(1535)	1929	(1751)	1968	(2572)
1862	(2186)	1930	(1865)	1978	(2314)
1886	(1446)	1933	(2212)	1986	(2382)
1894	(2078)	1948	(2140)	1995	(na.)

On the basis of these data, there does not appear to be any relationship between rainfall and flow pattern. It may be that when the whole record has been examined a pattern may be evident.

Rainfall at time of perigee or apogee

Similarly, it would be necesary to continue with a study of rainfall transposed to lunar months to see whether there is any coincidence of high or low rainfall with time of perigee or apogee.

Weather and Eclipses

Finally, it is known that during an eclipse of the sun, the regions of the earth affected by it experience reductions in the amount of energy received, the amount of the reduction depending on the type and duration of the eclipse. The location of the regions affected depends on the path of the eclipse.

In conclusion, I am continuing the study of rainfall data to see whether there is any clearer relationship between these events either singly or in combination.

Acknowledgements and References

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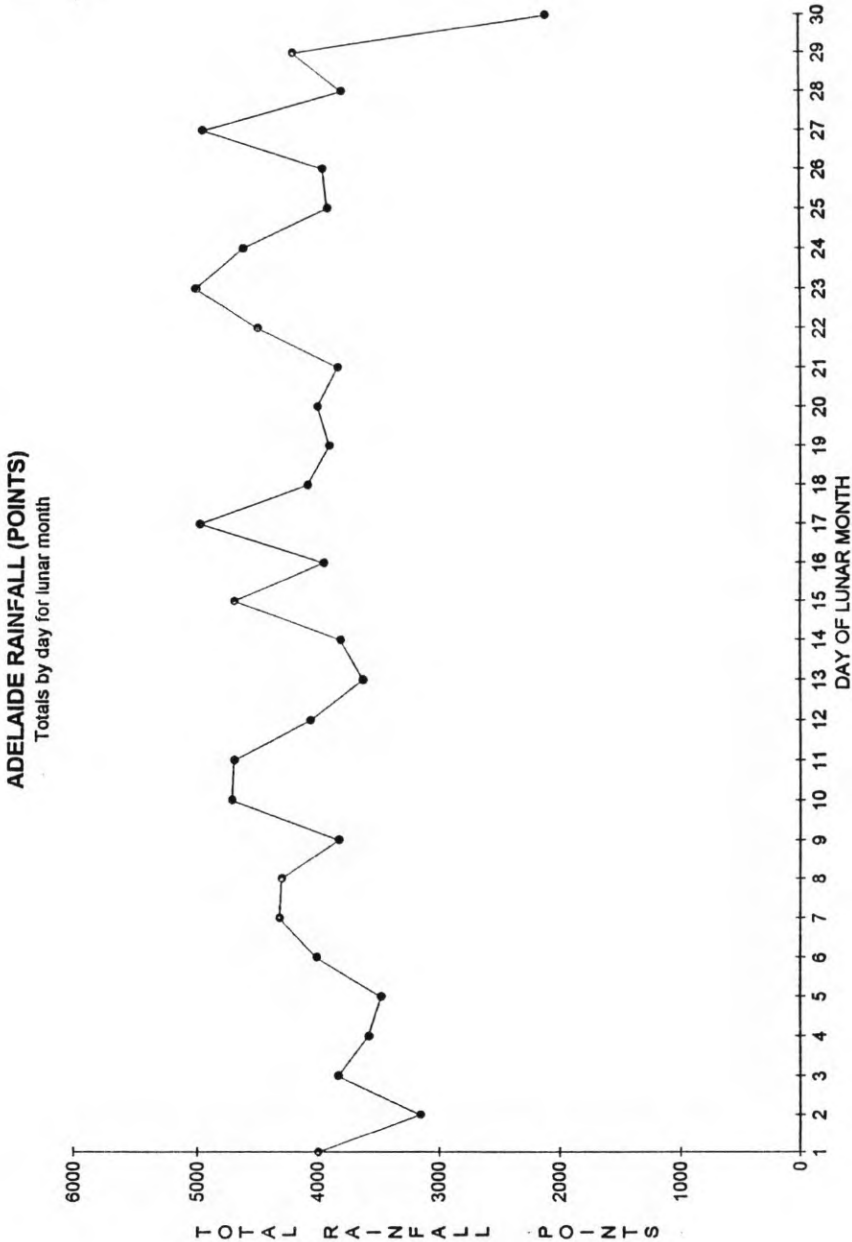
ADELAIDE RAINFALL (POINTS) 1911 - 1970
Daily totals tabulated by Lunar Month

TABLE 3

Day of Lunar Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	TOTAL	3-day Moving Average	5-day Moving Average
1	128	218	194	261	488	493	367	593	371	324	441	116	3994		
2	83	60	145	156	397	510	233	353	316	300	330	271	3154		
3	90	77	81	411	628	521	535	366	364	305	160	291	3829	3659	
4	65	80	51	363	329	675	498	529	229	237	135	389	3580	3521	
5	166	94	55	372	430	315	473	506	274	180	151	461	3477	3629	3607
6	136	242	177	386	676	356	440	464	595	235	126	181	4014	3690	3611
7	73	211	151	275	583	481	579	492	491	400	259	333	4328	3940	3846
8	291	71	292	277	666	449	697	424	347	296	287	214	4311	4218	3942
9	195	320	182	189	446	379	550	559	210	326	249	224	3829	4156	3992
10	154	153	200	359	458	818	732	539	369	490	215	241	4728	4289	4242
11	48	199	98	186	663	707	366	789	543	394	420	298	4711	4423	4381
12	78	41	49	450	389	882	442	385	565	373	235	185	4074	4504	4331
13	85	82	84	291	463	564	476	391	385	408	168	238	3635	4140	4195
14	165	370	145	195	707	525	284	403	287	311	252	179	3823	3844	4194
15	149	868	98	269	615	725	397	438	189	434	389	144	4715	4058	4192
16	206	238	98	370	544	561	679	398	339	195	196	142	3966	4168	4043
17	105	688	323	519	564	460	593	535	623	255	190	145	5000	4560	4228
18	108	175	265	398	557	379	398	485	388	355	210	384	4102	4356	4321
19	225	126	111	328	596	305	473	545	599	259	223	130	3920	4341	4341
20	308	57	159	268	717	351	348	662	472	349	155	174	4020	4014	4202
21	113	84	115	440	599	358	536	403	411	235	186	371	3851	3930	4179
22	39	156	430	300	507	621	683	551	518	344	232	147	4528	4133	4084
23	57	831	320	260	801	353	596	247	404	559	337	277	5042	4474	4272
24	254	191	228	248	512	921	610	363	294	373	499	159	4652	4741	4419
25	214	79	214	186	368	656	585	524	538	252	220	108	3944	4546	4403
26	45	108	26	631	378	384	581	469	455	270	251	385	3983	4193	4430
27	426	120	73	399	683	607	653	530	609	337	259	288	4984	4304	4521
28	203	15	17	238	365	385	460	435	589	444	296	375	3822	4263	4277
29	313	98	146	292	413	540	523	488	498	357	309	256	4233	4346	4193
30	127	118	28	255	250	230	216	115	192	400	204	12	2147		

FIGURE 1


ADELAIDE RAINFALL (POINTS)
Totals by day for lunar month
TOTAL RAINFALL POINTS
6000
5000
4000
3000
2000
1000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
DAY OF LUNAR MONTH

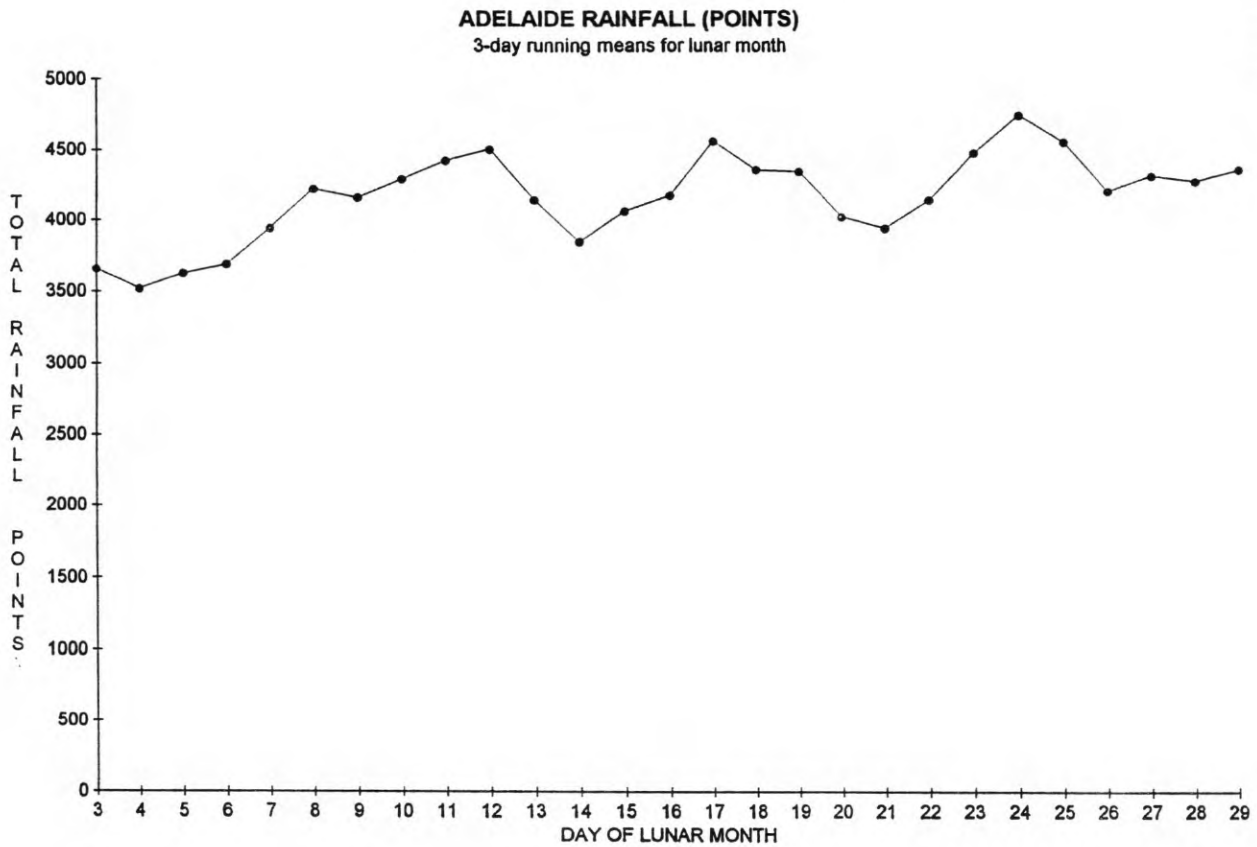
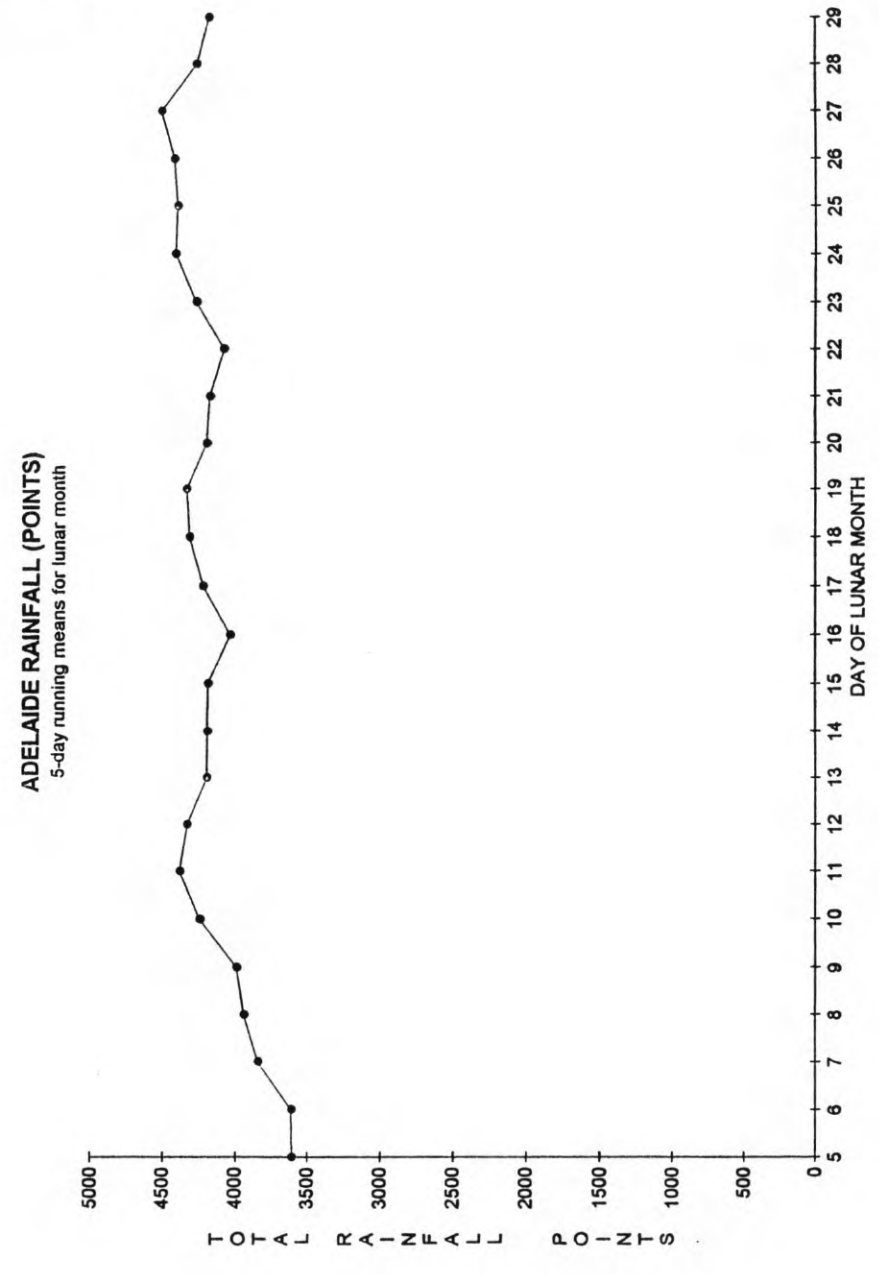

ADELAIDE RAINFALL (POINTS)
3-day running means for lunar month
TOTAL RAINFALL POINTS
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
DAY OF LUNAR MONTH

FIGURE 2

FIGURE 3


ADELAIDE RAINFALL (POINTS)
5-day running means for lunar month
TOTAL RAINFALL POINTS
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
DAY OF LUNAR MONTH

A Weatherwise Mariner Asks - Why?

Robert J. Symon

Transcribed and edited by John Pethic from a talk given to the association on August 15, 1994

I am here to explain the phenomenon of the unexplained strong winds at Troubridge Island. I am a past president of the Friends of the Paul McGuire Maritime Library and am chair person of the Paul McGuire Award for Maritime Achievement. Professor Geoff Lennon of the National Tidal Facility which was based at Flinders University was a recipient of the award, and some of the work of the Facility has been able to assist me tonight.

The Sea Surface Temperature chart for April, which I am displaying tonight, was kindly provided by Mat Tomczak and Michael Hersfeld of Flinders University.

Troubridge Island and its sandy shoals are just off Edithburgh on the western coast of St. Vincent Gulf, where the gulf widens before connecting with the open sea to the south and south-west. The gulf is closed of course to the north.

During the autumn period and sometimes as late as July we get warm currents occurring through the Troubridge Is area - warm water that actually doesn't really move out of the gulf, but oscillates. It tends to be pushed down the gulf and then the currents coming from the west tend to push it up again. At this time of the year, and again in October when there is generally an increase in tide (flood), what takes place with these currents circulating around the island is that we get a lot of warm water flowing in at the surface and below that the heavier (more dense) water flowing out simultaneously. That is, while the upper layers are flooding the deeper layers are still ebbing.

This is accompanied by radiation of heat from the water surface, warming the air, which continues on until the tide is at about three quarters high tide. If the conditions are ideal, the dispersion of latent heat in vapour from the water surface and the increased temperature of the air assist the formation of a localised low pressure area around the island. There is a slow but definite build up of wind. This can happen during the daytime. The sky may have one eighth of cloud cover, the winds are light and variable, perhaps with an easterly tendency. Towards high water there is a tendency for quite a rapid and big drop in barometric pressure, and suddenly we get winds up to one hundred and ten knots. They may build up to this ferocity and last for half an hour or more.

Now this might sound quite incredible but I have had venturi type anemometers on the island and each time this phenomenon occurs, it actually blows the rotor out of the anemometer and sucks up the liquid from the indicator in the office. Ultimately we decided to give this type of wind measuring equipment away. I am pretty sure of the velocities.

I was on the island for ten years and in that period this phenomenon would occur possibly twice or three times in a year. Principally it seems to occur in the Autumn, but it does also appear about once towards the middle or latter part of spring. My interest in observing this is the main reason for being invited along to talk to you tonight.

It has been very very dangerous down through the years. I have searched through the logbooks, since 1856 when the lighthouse was commissioned and in that time there have been a number of unexplained fatalities in the area. In the logbooks, which can be accessed through the Commonwealth Archives, you can see the reports of these winds. Back in those days they had very small water tanks (water has always been a problem on Troubridge Is) and often the tanks would be blown away even though they were wired down. My conclusions are only reached from my ten years on the island but the existence of these winds is confirmed in the earlier logs.

The particular tidal patterns lock relatively warm water in the area and allow the transfer of heat to the air above with enough energy to create a localised low in the area. This creates a type of vortex, with an estimated diameter of about 4 to 4 1/2 nautical miles. I have made reports about this in my logbooks, although unfortunately my earlier logbooks have gone missing. I believe that this is a local phenomenon that occurs unexpectedly from time to time, and which can be extremely dangerous.

Be alert to the fact that if you have a boat moored near Troubridge Island in Autumn or Spring you are in danger of experiencing these wind conditions.

In 1942 I was on a vessel that was torpedoed in the Indian Ocean just as one comes out of the Mozambique Channel, between Mozambique and Madagascar. When we got away the sea was an oily calm. With two land masses on either side and during the evening the warmth was coming up from the water and the same turbulence occurred. We were on a lee shore and the seas became so serious that we wondered if we would get safely to shore. Fortunately we were able to sail into Durban.

Another place where I have encountered this was in the Red Sea, but this may have been due to other conditions. Here we have two land masses and each of them radiating lots of heat creating locally dangerous winds.

Wake-up and Cover-up!

Peter Glade-Wright
Executive Director , Skin Cancer Research Foundation (SA) Inc.

Summary of talk given to the Association

Australia has the highest incidence of skin cancer of any country in the world, 10 times higher than the USA and 25 times higher than the UK. In Australia about 1000 people die quite needlessly each year from this insidious disease.

The main cause of skin cancer is exposure to Ultra-Violet Radiation, or UVR. What is it? It is part of the "light" spectrum, shorter in wavelength than visible light and hence invisible. UVA has wavelengths in the 315 - 400 nanometer (nm) part of the spectrum. It penetrates deep into the skin and contributes to cancer formation and premature skin ageing. UVB is shorter in wavelength, from 280 - 315 nm and contains much higher energy. It is absorbed in the upper layers of the skin or epidermis and is the main cause of sunburn and skin cancer.

UVR levels have been recorded by the SKIN CANCER RESEARCH INSTITUTE for the past three years in South Australia and during the summer months the Institute has alerted the public to high risk days by issuing skin damage warnings through all the media.

On certain days this year (1992) we have recorded UV levels up to 10% higher than the norm for that time of the year. It has been estimated by world authorities that for each 1% increase in UVR, the risk of skin cancer increases by 3 - 5%. The main reason for this sudden increase is OZONE DEPLETION in the atmosphere. For each 1% loss of ozone an extra 2% of UVR will reach the earth's surface.

Ozone is a gas, a constituent of the atmosphere which envelops the earth and which under "normal" conditions blocks out 99% of the harmful UVB rays. Ozone is destroyed when man-made gases such as chlorofluorocarbons (CFC) and halons enter the atmosphere. This, combined with the "Antarctic ozone hole" discovered by British scientists in 1985 and now thought to be a natural occurrence, gives us all reason for concern. Not only are we faced with increased UVR, but it may also have an influence on the earth's climate. One effect may well be a decline in food and timber production as increased UVR may decrease chlorophyll formation, leaf size and seed germination. Food chains in the oceans may also be depleted through the destruction of plankton and fish.

Skin cancer can no longer be thought of only as someone else's problem. More than 50% of Australians will have some form of skin cancer in their lifetimes. It is well documented that the majority of skin damage occurs in the first two decades of life. This is due to a number of reasons: A child's skin is more delicate and sensitive to UVR exposure; more time is spent outside in the sun particularly in the hours of peak UVR (10 am to 2pm, or 11am to 3pm during daylight saving); clothing tends to be

less suitable or less protective to exposure, and there is less attention paid to safe sun practices.

It must be made clear that just one severe sunburn in early childhood more than doubles the risk of melanonoma in later life.

The practice of putting infants out on a rug in the sun without clothing should be stopped. In fact, children under the age of twelve months should always be kept out of the sun. At this age their melanin production has not developed sufficiently give any protection to their skin. At birth, one's skin is pure, that is unblemished, without moles, freckles and so on. The skin cancer you get at age 60 is from damage as a child. Damage is cumulative, the burn may disappear but the damaged cells remain.

Other effects from exposure to UVR are freckles, leathery and mottled skin, premature skin ageing, loss of elasticity and serious eye damage such as cataracts, pterygium and conjunctivitis. Perhaps more important, our body's immune system may be supressed.

There is no such thing as a safe tan. To get a tan, skin damage has first to occur.

A further point to keep in mind is that even on cloudy days you can still do skin damage. Even while sitting in the shade you can be burned by UVR reflected off light coloured surfaces. UVR can be received not only directly from the sun, but also by reflection from surfaces such as water, sand, snow or any light coloured surface.

It is never too late to do the safe thing and "cover up". As mentioned above, children up to the age of twelve months should be kept out of the sun altogether. If possible avoid exposure at the times of day with high UVR. Try to get into the shade but still "cover up". Always wear a broad-brimmed hat, apply 15+ broad spectrum sun screen on exposed skin, and don't forget your u-v sunglasses. The sun screen should be applied 15 to 20 minutes prior to going into the sun and re-applied if you are remaining in the sun.

One should regularly examine the skin and be aware of any lumps, bumps, moles or spots that won't heal or that change in size, shape or colour, or that itch or bleed. Whenever in any doubt, see your doctor. Dermatologists claim that 99% of all skin cancers can be treated successfully if treated early enough.